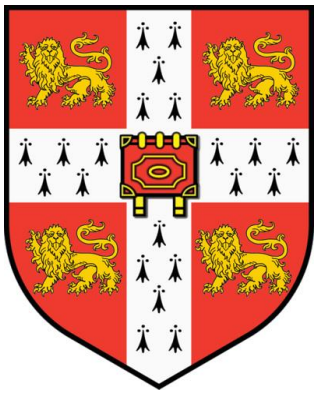
Socio-material constructs of domestic energy demand:
Household and housing practices in Pakistan



Dissertation submitted for the Degree of Doctor of Philosophy

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ABSTRACT

Domestic energy demand in the Global South is predicted to grow to nearly three times that of the developed nations by 2040, under rapid urbanisation, economic development and the emergence of a new, high-consuming middle-class. Current energy policy, with its largely technological template and economic focus fails to address the ways of living and patterns of demand that emerge and evolve as a result of the specific socio-material and cultural contexts that underpin how the need for energy arises and evolves. This research adopts a socio-technical perspective to explore various nexuses of practices and spatial arrangements of urban housing that have emerged, persisted and transformed over time, giving rise to unsustainable levels of electricity consumption in middle-class housing in Lahore, Pakistan. It further investigates how household practices fit within the wider system of housing practices and how this can inform low-energy interventions in house design and use.

The research combines practice theories from the social sciences with architectural knowledge of spatial agency to explore the interlinked social and material structures that form domestic electricity demand. This is achieved through a mixed-methods approach including semi-structured interviews with homeowners and housing practitioners, cross-cultural comparative analysis, house case-studies, oral history narratives, environmental monitoring, spatiotemporal mapping of household practice-arrangements through time-use diaries as well a detailed review of archival documents relating to building regulations and house plans.

The study highlights the significance of local socio-material and cultural context in everyday household practices and resulting electricity demands. It reveals that understanding the longitudinal dynamics of practice-arrangements and their diversity in cross-cultural contexts can help identify and prevent normalisation of unsustainable configurations that gradually become embedded in social structures and practices. It shows how a shift from outdoor to indoor activities, transformation from inward- to outward-oriented design and a spatial dispersion of practices have resulted in increased household electricity consumption. It further highlights the implications of cross-cultural transfer of technology and demand response strategies that are bound by local socio-cultural and material dynamics in the performance, bundling and synchronisation of practices. The study makes the connections between “good” and “bad” housing and household practices visible and identifies various energy transitions needed in housing practices that, through interventions in house design, can lead to less energy intensive household practice-arrangements.

Key words: Energy demand, Household practices, Housing practices, Middle-class, Socio-technical, Global South

Dedicated to my daughter, Zoeya

...a fitting end to three years of separation

ACKNOWLEDGEMENTS

"...Any who is grateful does so to the profit of his own soul..."
(The Qur'an- 31: 12)

I am truly privileged to have achieved this PhD. Keeping in line with a practice-theory approach, I can claim with certainty that practicing this PhD has certainly not been an individual endeavor, but a collective effort that involved interconnections and interrelations with many other practices, the agentive power of many different stakeholders and challenged many a socio-material norm in its making. To say that the last three years have completely changed my view of the world would not be an exaggeration by any means.

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and work better. Minna also introduced me to practice theory when I was initially struggling to make sense of occupant behaviour in building energy efficiency, for which I will forever remain grateful.

I am also thankful to Prof Koen Steemers for his mentoring and for giving me the opportunity to work on the UserTEC project, funded by Innovation Fund Denmark, that allowed me to meet some amazing people like Prof Kirsten Gram-Hanssen and Dr Toke Christensen. I learned a lot from them and had the good fortune of publishing a joint paper, as part of this dissertation.

I would also like to express deep gratitude to all the interview and case-study participants from Pakistan, who took valuable time out from their schedules and opened their homes and houses to me. This empirical research would not have been possible without them. I would also like to thank the Walled City of Lahore Authority, the Lahore Development Authority, the Cooperative Model Town Society and The Punjab Archives in Lahore for all their assistance. I thank the anonymous reviewers who gave valuable feedback on the journal papers and helped me to refine my thinking and writing skills. I am thankful to the Behaviour and Building Performance (BBP) research group at the Department of Architecture for their support. It provided a good sounding board and much needed respite from research and writing in times of stress. It was a pleasure being a part of the BBP group.

In the end, I would like to thank all my family and friends, whose encouragement and support made this journey possible. I am especially thankful to my family, who were as invested in my getting a doctorate as I was, if not more. I am grateful to my in-laws, who prioritised my education and academic dreams over upholding customary cultural responsibilities and supported me all the way. I am indebted to my parents; whose sacrifices are beyond description. I am what I am today because of them. Last but not the least, I am eternally thankful to Allah Almighty for my husband Adeel, who kept me sane and whose blood, sweat and tears have gone into much of this writing. You are my lifeline.

Statement Page

Title: Socio-material constructs of domestic energy demand: Household and housing practices in Pakistan

PhD Student: Rihab Khalid

Supervisor: Dr Minna Sunikka-Blank

This thesis is based on the following original publications which are referred to in the text as Papers 1-4.

Paper 1	**Khalid, R.**, Sunikka-Blank, M., 2017. Homely social practices, uncanny electricity demands: Class, culture and material dynamics in Pakistan. Energy Research & Social Science 34, 122–131. https://doi.org/10.1016/j.erss.2017.06.038
Paper 2	**Khalid, R.**, Sunikka-Blank, M., 2018. Evolving houses, demanding practices: A case of rising electricity consumption of the middle class in Pakistan. Build. Environ. 143, 293–305. https://doi.org/10.1016/j.buildenv.2018.07.010
Paper 3	**Khalid, R.**, Christensen, T.H., Gram-Hanssen, K., Friis, F., 2019. Time-shifting laundry practices in a smart grid perspective: a cross-cultural analysis of Pakistani and Danish middle-class households. Energy Efficiency.1-16. https://doi.org/10.1007/s12053-018-9769-7
Paper 4	**Khalid, R.,** Sunikka-Blank, M., 2020. Housing and household practices: Practice-based sustainability interventions for low-energy houses in Lahore, Pakistan. *Energy Sustain. Dev*. 54, 148–163. https://doi.org/10.1016/j.esd.2019.11.005

Author's contributions

In all four journal papers, the author acted as the corresponding author and led the paper development with the main responsibility of writing the paper.

In Paper 1, the author designed the research on energy demand in middle-class household practices, conducted fieldwork in the ten case-study houses, transcribed and coded the interviews, analysed the data and extracted the main findings. The author's supervisor Dr Minna Sunikka-Blank, who is a co-author on the paper, supervised the research design and provided support and guidance throughout the process. She reviewed the final paper draft providing valuable comments and feedback, which guided the writing of the Conclusion section.

In Paper 2, the author was responsible for designing the research on the longitudinal analysis of household practices and spatial arrangements, conducting the fieldwork in the five case-studies, and collecting archival data on building regulations and house plans. The author was also responsible for interview transcription and coding, data analysis, conceptualising the three themes that determine the process of change in household practice-arrangements and writeup of the key findings. Minna, co-author on the paper, provided valuable feedback throughout the research and writing process and reviewed the paper draft and helped in formulating the Conclusion section.

Paper 3 is the result of a collaboration with the Danish Building Research Institute, Aalborg University, as part of the UserTEC project, funded by Innovation Funds Denmark. The author was responsible for conducting the Pakistani case-study, and for collecting and analysing the data. The Danish case-study was undertaken by Dr Freja Friis, under the supervision of Prof Kirsten Gram-Hanssen and Dr Toke Haunstrup Christensen. The author was also mainly responsible for the paper development. This included structuring the paper and writing the Introduction, literature review (Dynamics of household practices and energy demand), Method, Discussion and Conclusion sections. In the Findings section, the general overview and the Pakistani case (Time-shifting laundry practice in Pakistan) were written by the author. Toke was responsible for writing the findings of the Danish case (Time-shifting laundry practice in Denmark). Toke and Kirsten further provided valuable feedback and guidance to the author in writing the paper.

In Paper 4, the author was responsible for designing the research on housing and household practices and their interconnections in relation to energy demand, conducting fieldwork in the two critical case-study houses, conducting interviews with professional experts, collecting and analysing the data, as well as structuring and writing the paper. Minna, co-author on the paper, provided valuable guidance throughout the research and writing process as the author's PhD supervisor. She also guided the structure of the paper and provided feedback on the paper draft and helped in formulating the Conclusion section.

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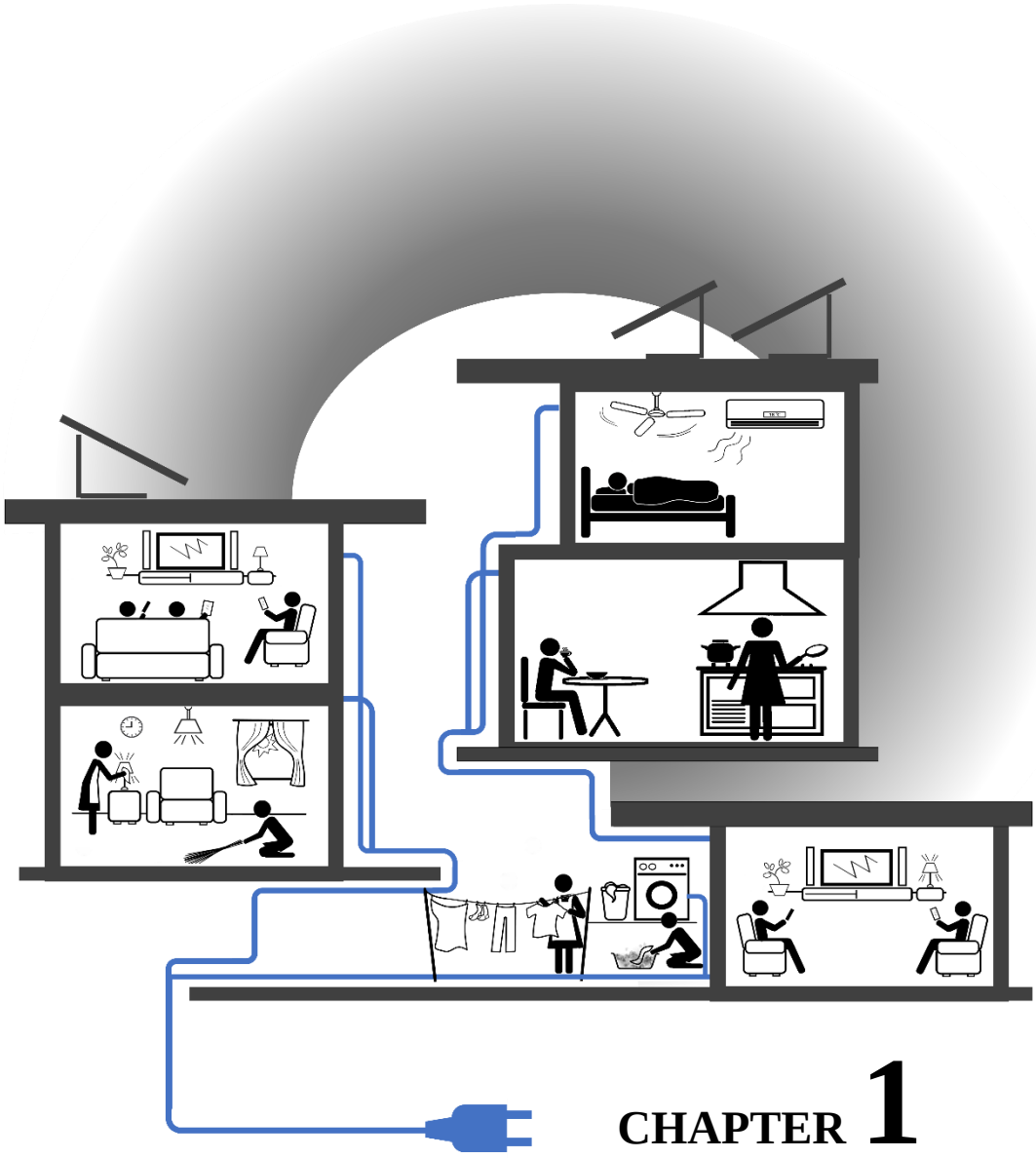
PART I

INTRODUCTION

Part 1 is comprised of two chapters. Chapter 1 presents an introduction to the research area, forms a background context, identifies the gap in existing research and finally leads to the research questions, aims and objectives. It also presents a brief introduction to the methods and theoretical framework adopted in the research, followed by the limitations of the research and scope for further study. Chapter 2 presents literature review on household energy demand in energy use studies, placing the methodology adopted within the wider field of energy studies. It reviews contemporary practice theories and analyses their application in energy use research. Finally, it draws on a framework of using practice as a unit of analysis and as a unit of intervention for improved efficiency and sustainability, that is applied in the empirical chapters of the thesis.



CHAPTER 1

1. Introduction

A family in an upper middle-class neighbourhood in Lahore had, in recent years, installed all the latest state-of-the-art gadgets and appliances in their house, much to their satisfaction. Their only cause for concern was the exception of a twenty-two-year-old semi-automatic washing machine, left unreplaced owing to the housemaid's lack of skills in operating a new automatic one.

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In another middle-class household in a different neighbourhood, a family was found in a state of indecision on whether to buy a fourth refrigerator for their eight-member, multi-generational household. The only obstacle in their way was their son's apparent reluctance on what his friends and neighbours would think in view of their extravagance and the image of wastefulness it portrayed.

*****

Not far away, another middle-class family moved into their newly built house. The household took special pride in the huge glass windows and imported glass parapets on the roof terrace. In the two years since, the terrace remained unused and the windows remained shut with thick curtains drawn due to massive heat gains and issues of privacy.

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In 2014, Shove and Walker posed the question, 'What is energy for?'[1]. Their question was in response to the dominance of engineering and scientific models of energy as an abstract resource obscured in the management and organisation of political, economic and technological systems. While these may be important, the authors contested that such a narrow view of energy demand overlooked the specific socio-material and cultural contexts that underpin 'how the need for energy arises' or 'how such needs evolve' (2014, p. 42). Energy, although an intrinsic part of the daily routines and practices in households, remains 'visibly invisible' and its demand: uncertain and unpredictable. The authors' socio-technical perspective challenged the basic assumptions associated with energy demand and provided a good starting point for an alternative understanding of energy as a consequence of the social dynamics and temporalities of everyday routines and practices;

> '…energy supply and demand are realized through artefacts and infrastructures that constitute and that are in turn woven into bundles and complexes of social practice.' (Shove and Walker, 2014, p. 42)

This socio-material construct of energy presents demand not as 'an input to provide products and/or services' (EIA, 2018) but as 'an outcome of what people and organisations do' (Walker, 2014, p. 49) in the form of social practices. Thus energy becomes an ingredient of practices that are configured by the co-constitutive institutional systems, shared cultural norms and values, knowledge and skills as well as the vast array of material objects, technologies and infrastructures (Shove et al., 2012). Thus, instead of focusing on individuals, citizens or macro-scale socio-technical systems, the basic unit of analysis for understanding change and continuity of the social order is taken as practices. Societal transitions are thus seen as emerging in the generation and circulation of elements of which practices are made (Shove and Walker, 2010).

Social practices emerge and transform interdependently with the spaces, places and material arrangements they occupy. A socio-technical approach to energy consumption reveals the embedded nature of energy demand in mutually dependent social and material structures. In this, the architecture of the built environment plays a critical role. Buildings help to define and stabilise order in society. Gieryn (2002) depicts buildings as 'objects of (re)interpretation, narration and representation' which continue to be constructed and deconstructed, both materially and semiotically as society transitions and evolves. He suggests an inherent duality of structure and agency in buildings, in that buildings are physical manifestations of the advancements, valued norms and aesthetics of a society, but once erected and occupied, they serve to mould societal aspirations, define social institutions and networks and structure patterns of use and consumption. In the famous words of Winston Churchill, "We shape our buildings and afterwards our buildings shape us." (Brand, 1994, p. 3)

[1] Reference to the title of paper by Shove and Walker (2014)

Current energy policies, with their largely technological template and economic focus on individual behaviour change fail to address the ways of living and patterns of demand that are as much social issues as technological ones. Most building demand and sustainable intervention policies tend to focus on improvements and efficiencies in the building materials and systems of supply (Shove and Walker, 2010), and overlook the constraints and enablement of various forms of 'human-material entanglement' (Shove, 2017, p. 6). Through such an approach, energy use practices are accepted as a constant, unquestioned and taken-for-granted need to be met as efficiently as possible. This makes sustainable changes in everyday practices limited, impractical and non-negotiable, resulting in 'change of no change' (Marres, 2011, p. 529). Instead of considering buildings simply as grounds for technological efficiency in construction and appliances, there is a need to view architecture as 'the material counterparts of competing social practices' (Guy and Shove, 2000, p. 67). The dynamics of the socio-material constructs that define practices and their subsequent energy demands are as much driven by global technological advancements and uniform standards as they are dependent on contextual socio-cultural norms and values (Shove, 2003).

This dissertation looks at expanding knowledge of the social and material constructs of domestic energy demand that shape electricity consumption in middle-class houses in Lahore, Pakistan, from a socio-technical perspective. By combining practice theories from the social sciences with the concept of spatial agency in design from the field of architecture and architecture as 'mediator' from STS, the thesis undertakes a detailed analysis of household and housing practices in Pakistan with the aim of exploring a framework for potential pathways to low-energy sustainability interventions in house design and use.

1.1. Energy use in context- the case for Pakistan

Pakistan, like many other developing countries in the Global South, has seen rapid urbanisation and economic growth, together with increased vulnerability to climate challenges since the turn of the century (Karakosta and Askounis, 2010; Aziz et al., 2013). The issues facing energy sector development continue to act as the key constraints in Pakistan's economy (Masood, 2010) with the country facing ever-increasing gaps between energy supply and demand (HDIP, 2018). The escalating energy demand growth, increased standards of comfort (e.g. see Ghani, 2014; Hansen et al., 2016; Wilhite, 2008) and the recognition of the role of occupants (Stern, 1992; Janda, 2011) in energy consumption have highlighted the need for taking a proactive approach to closing the energy demand-supply gap, by focusing on energy demand management strategies to reduce consumption, instead of simply augmenting supply to meet demand (Torriti et al., 2010).

In Pakistan, as in many other countries in the Global South (see e.g. Brew-Hammond, 2010; Oonsivilai and Greyson, 2009; Salama and Al-Sumaiti, 2014), the common practice for demand management is electricity load-shedding, where power is shut down intermittently for 6-8 hours in

urban centers and even longer in rural areas- an approach that serves as the last resort to overcome these gaps. Estimates show that load-shedding has resulted in 3-4% GDP losses in Pakistan, costing roughly GBP11 billion annually to the country's economy (as cited in Aslam et al., 2015). Where power outages have had severe macro-level economic consequences, they have also resulted in socio-cultural impacts at the meso-micro level of households, disrupting the daily routines and practices of homeowners, further asserting the need for improved demand management.

In Pakistan, domestic energy demand accounts for 22.63% of the total energy consumption (HDIP, 2018). In terms of electricity demand, the domestic sector accounts for the highest consumption, with a total of 51.0% (HDIP, 2018). Economic welfare and increased reliance on technology and electrical appliances by households in recent years have made the urban domestic sector more energy intensive (Bhutto and Yasin, 2010; Chaudhry, 2010; Ghani, 2014), hence offering potential for improved energy conservation (Jan and Mutalib, 2013).

During the first decade of the 21st century, the middle-class[2] in Pakistan grew from 32% to 55% of the total population and accounted for 90% increase in national consumption (Ghani, 2014). Although urban residential consumption is on the rise, estimates reveal a housing shortage of roughly 10 million units and the deficit continues to grow, particularly in urban areas (World Bank, 2017). Ownership of this housing stock is concentrated in the middle- and upper-income bracket and constitutes the bulk of urban domestic energy demand. This is because in 2001, under the growing pressure of housing backlog, the National Housing Policy revised the role of government as major housing provider to that of facilitator, empowering other stakeholders, specifically private sector and non-governmental organisations. Consequently, the financial share of housing in public sector development declined; from 10.9% in the First Five Year Plan to 5.9% in the Seventh Five Year Plan (MoHW, 2001). National housing policies thus prove inadequate in dealing with the current housing shortage. In addition, they fail to consider the energy efficiency of the existing housing stock (MoHW, 2001; Tiwari and Rao, 2016).

As for national energy policies, the urban domestic sector is mostly overlooked by policy-makers who primarily focus on energy generation (Alahdad, 2012) or improvements in rural areas (Bhutto et al., 2011; UNDP, 2018), with limited focus on energy demand management. Whilst power shortage and rising electricity costs have been viewed dominantly through the lens of the supply side, there is a consistent lack of focus on the steady growth in demand, particularly from households.

The sole body dealing with energy efficiency is The National Energy Efficiency & Conservation Authority (NEECA, previously known as ENERCON: the national Energy Conservation Center), formulated in 1987 as a subdivision of the Department of the Ministry of Water and Power of the

[2] In Pakistan, the middle-class households are defined as having daily per capita expenditures of US$2-US$10 (in 2005 purchasing power parity dollars (Ghani, 2014)).

Government of Pakistan. It serves as a federal agency for mandating the initiation, coordination and operation of all energy conservation related activities in all sectors of the economy. Its key responsibilities include formulation of energy conservation policies of the country and over-seeing energy efficiency programmes nation-wide. NEECA, in collaboration with Pakistan Engineering Council (PEC), formed the Building Energy Code of Pakistan-Energy Provisions 2011, established as part of the building byelaws in 2014. The code was designed to provide minimum requirements for energy efficient design and construction of buildings. It defines minimum standards in building envelopes, HVAC systems, service water heating, lighting and electric power. In each category, strict technical standards are provided, such as minimum thermal conductance and insulation for walls and roofs, min/max temperatures for cooling and heating, minimum equipment efficiency, etc. As a result of these energy provisions in the building codes, NEECA estimates energy savings of up to 25-30% in new buildings. This estimate is highly questionable for several reasons: first, the codes are based on the American Society of Heating, Refrigeration and Air conditioning Engineers (ASHRAE) standards, and so may not be wholly suited to Pakistan's climate and local needs. Second, the codes only target high-end public and commercial buildings with areas of 1200sq.m or more, without specifying any efficiency standards for housing. Finally, whilst the codes target technical efficiency standards, there is limited focus on passive design considerations, such as building form, orientation and solar shading, and none on occupancy and use. This reveals serious gaps in Pakistan's energy conservation policy. Further, compliance with the codes has only been mandated for new buildings or for alterations in existing buildings, thereby dismissing any efficiency improvements in the existing building stock.

These factors indicate the need for improved demand management strategies in Pakistan's middle-class housing, specifically with a socio-technical approach to reducing energy consumption. A socio-material construct of the domestic energy demand necessitates an analysis of the material infrastructure and energy systems together with the unique set of inter-linking ideologies, norms and pace of progress that shape the continuity and change of practices in the country, as posited by Qadeer (2006);

> 'In the consumption and adoption of new products, Pakistanis respond opportunely, but in family values, gender relations, and political and religious beliefs they tack close to traditions in meaning and function, even if not in form.' (2006, p. 137)

This complex interplay is evident not only at the macro level but manifests itself in intricate detail at the household level and shapes the everyday routines and practices of homeowners. Housing and household energy demand is a complex phenomenon (Hitchcock, 1993; Stern, 2014), that requires analyses through a multi-dimensional lens of the climatic, socio-economic, political and cultural

context. It is only through such an approach that the 'energy efficiency gap' (Schmidt and Weigt, 2015, p. 209) in energy-use research can be overcome and the fallacy of a 'value-action gap' (Shove, 2010, p. 1276) be overruled.

1.2. Research aims and questions

This dissertation undertakes the study of domestic energy demand at the interface of the social (institutional systems, shared cultural norms, values, meanings, knowledge and understandings) and material (objects, appliances, technology, building design, infrastructure and energy systems) structures that shape housing. Therefore, this dissertation investigates the socio-material constructs of domestic energy demand in the electricity consumption of middle-class houses in Lahore, Pakistan from a socio-technical perspective. A comprehensive understanding of these socio-material structures is developed through practices. Further, the study aims to explore low-energy interventions in house design and use. The thesis aims to answer the following two broad questions, further sub-divided into six sub-questions explored in the four empirical chapters;

I. What are the characteristics of household practices that drive electricity demand in middle-class houses in Lahore, Pakistan?	**Part II: Practice as unit of analysis**
1. How do the material arrangements adapt to and shape everyday household practices and the resulting electricity consumption? 2. What role do the socio-cultural dynamics play in structuring homeowners' daily practices and the resulting electricity consumption?	Ch. 3 (Paper 1)
3. How have the socio-material structures of household electricity demand evolved in middle-class houses in Lahore and what lessons can be learned from this historical analysis?	Ch.4 (Paper 2)
4. How does household electricity consumption relate to practice temporalities and materiality in different cultural contexts and what are the implications for energy demand management?	Ch. 5 (Paper 3)
II. How do household practices fit within the wider systems of housing practices and how can this inform sustainability interventions in house design and use in Lahore, Pakistan?	**Part III: Practice as unit of intervention**
5. How does the house design mediate electricity consumption in household practices? 6. How can interventions in housing practices lead to less-energy intensive household practice-arrangements?	Ch. 6 (Paper 4)

Part II focuses on the identification and understanding of the social and material structures that shape domestic electricity demand. This is undertaken through an analysis of contemporary household practices (research questions 1 and 2), a longitudinal analysis of household practices and house spatial layouts (research question 3), and a cross-cultural comparative analysis of similar household practices in different socio-cultural contexts (research question 4). Here, household practices refer to the routine domestic practices and chores like cooking, cleaning and laundering, etc. that take place within the house and in their performance, consume some form of energy. In the present case, the analysis is restricted to electricity-consuming practices (further details of selection and performance of household practices are given in section 1.3 and 1.4). Part III further develops the socio-material understanding of domestic energy demand by exploring the links between *household* practices of homeowners and *housing* practices of professional experts. Here housing practices refer to the designing, building and planning practices of practitioners associated with the provision of housing, including architects, builders and town planners, etc. Taking the house design as a key mediator between household and housing practices, the thesis first investigates how the house design influences routine electricity-consuming household practices (research question 5). It then goes on to explore how interventions in housing practices of professional experts can lead to changes in house design, which consequently result in low-energy interventions in household practices (research question 6). To summarise, whilst Part II focuses on the identification of the socio-material constructs of domestic energy demand through the lens of homeowners' practices, Part III builds on this analysis to design an intervention framework by linking household practices with wider housing practices.

The identification of the research questions and objectives based on existing evidence gaps in the literature, and the links between the various research questions are further explained in the next chapter, in section 2.6

1.3. Methods and scope

This dissertation takes a socio-technical approach to understanding domestic energy demand. This helps in providing greater insights into the mutually dependent social and material structures that shape domestic electricity consumption in middle-class housing in Pakistan. The research employs an interpretivist ontology and social constructivist epistemology (Figure 1). In doing so, it responds to the call for better integration and implementation of Social Science and Humanities (SSH)-related theories, methodologies and concepts to contemporary energy studies research (Sovacool, 2014; Sovacool et al., 2015; Foulds, 2018).

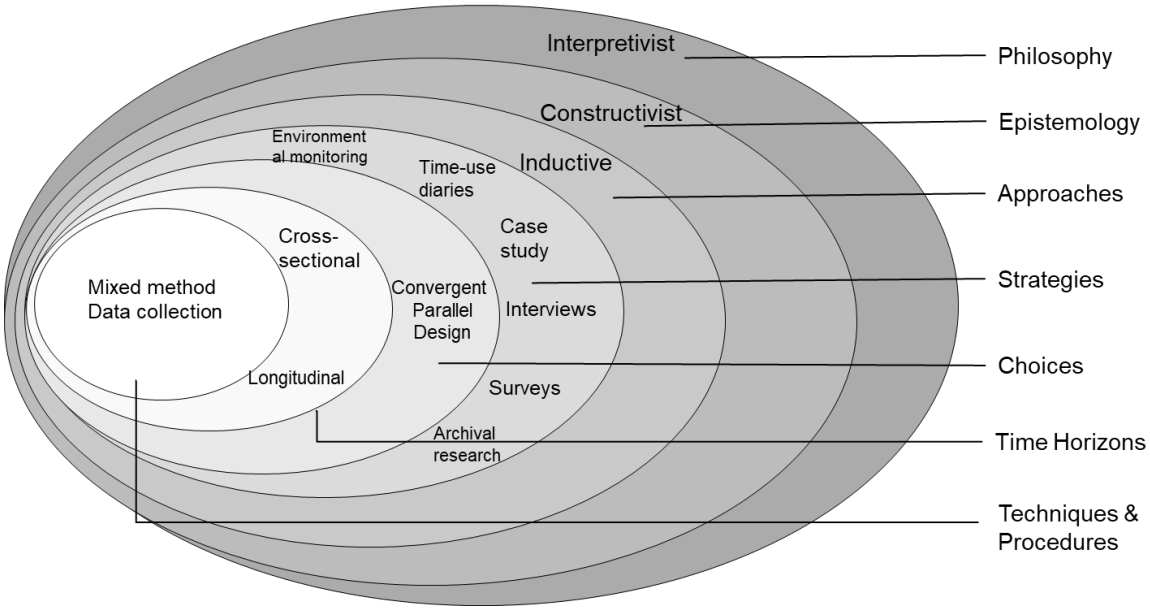


Figure 1: Research framework. (Source: Adapted from Saunders et al., 2003)

The investigation of domestic electricity demand was conducted through an analysis of household and housing practices in middle-class houses in Lahore, Pakistan. Pakistan presents an interesting case-study as a middle-income developing country in the Global South. The sixth largest country in the world in terms of population (~203 million in 2019), Pakistan has a GDP of 5.8%, with growth mainly driven by higher energy demand in an increasing urban middle-class population (Ghani, 2014). The country faces increasing vulnerability as a result of climate change (Kreft et al., 2015) with increasing gaps between energy supply and demand (HDIP, 2018) and a widening divide between the socio-economic classes in terms of income, wealth, urbanisation, spatial inequality as well as housing. Ownership of urban housing stock is mainly concentrated in the middle and upper-income bracket and constitutes the bulk of the domestic energy demand (Shaikh, 2016). Lahore, the case-study area, is the second largest city of Pakistan, with an estimated population in excess of 10 million. Lahore was selected as a case-study due to a representative group of middle-class households and its' on-going expansion with development of several new housing schemes that cater to middle and upper-income groups. The selection of Lahore was also based on the author's close affiliation with the city. Having been brought up and educated in Lahore, the author was intricately familiar with its landscape and acutely aware of the challenges it faces from unprecedented growth in its domestic energy demand. The case-study houses selected for this study are typical of housing in affluent Western-inspired modernistic developments that are becoming the norm, not only in Lahore but throughout Pakistan as well as in the wider South Asian region. In addition, the rising levels of middle-class consumption under growing aspirations and changing lifestyles investigated in this study are reflective of similar patterns observed throughout countries in the Global South (e.g. Hansen et al., 2016; Ho, 2015; Rinkinen et al., 2017; Wilhite, 2008)

Table 1: Summary of research methods and data for each empirical chapter

Empirical research	Research Focus /Objective	Theoretical framework	Methods	Data/Sample	Further sample details
Ch. 3 Paper 1	Characteristics of household practices and electricity demand	Practice elements (Shove and Pantzar, 2005; Schatzki, 2011; Bourdieu, 1984, 1997)	Case-study houses Household semi-structured interviews Questionnaire survey Transect walks Observation	10 middle-class case-study houses Interview audio recording Household demographics and electrical appliance ownership Spatiotemporal mapping Photography	Ch. 3, section 3.3. Table 5 provides household details and interview participant demographics.
Ch.4 Paper 2	Historical coevolution of household practice-arrangements	Practice-arrangement bundles (Schatzki, 2010a, 2011) Structure/agency of buildings (Gieryn, 2002; Bourdieu, 1970; Giddens, 1984a)	Case-study houses Oral history narratives Focus group discussion Document analysis	5 middle-class case-study houses 4 semi-structured interviews with older citizens, audio recorded 7 middle-aged housewives, audio recorded Old photographs, house plans, appliance ownership stats and building regulations	Ch. 4, section 4.2.2. Table 6 provides details of interviewees and case-study houses
Ch. 5 Paper 3	Comparative analysis of household practices in different socio-material contexts	Practice temporalities (Southerton, 2003, 2012; Walker, 2014) Material co-constituents of practice temporalities (Spurling, 2018) Practice as unit of analysis (Kuijer, 2014)	Pakistani case: Same as Ch. 3 Danish case: Household semi-structured interviews	Same data/sample as for Ch. 3 13 middle-class households, audio recorded	Ch. 5, section 5.3. Table 9 and 10 provide household details and interview participant demographics
Ch. 6 Paper 4	Low-energy interventions in housing (design) and household (use) practices	Architecture as mediator (Gieryn, 2002; Latour and Yaneva, 2008; Yaneva, 2009) Systems of practice (Watson, 2012) Practice intervention framework (Spurling et al., 2013)	Case-study houses Time-use diaries- Environmental monitoring Semi-structured interviews	2 case-study houses Spatiotemporal mapping of practices Temp & humidity data for 20 days at 5-min intervals 17 professional experts, including 11 architects, 3 town planners and 3 builders/developers, audio recorded	Ch. 6, section 6.2.2. Table 12 provides details of the interviewed housing practitioners. Table 13 and Table 14 provide details of the case-study houses and homeowners.

Owing to the interdisciplinary nature of the dissertation, a mixed-method approach was used for data collection, undertaken between 2016 and 2019. Table 1 presents an overview of the various methods employed and data collected in order to meet the research objectives undertaken in each of the four empirical chapters of the dissertation (see Appendix 1 for a detailed timeline of the fieldwork, showing distribution of the various primary and secondary data collected for each empirical chapter).

In Chapter 3 (Paper 1), research questions 1 and 2 were answered through data collection in ten middle-class case-study houses. In-depth semi-structured interviews and questionnaire surveys were conducted with homeowners in the summer of 2016 (see Appendix 1 for the fieldwork timeline). Whilst semi-structured interviews provided rich details of homeowners' practices, questionnaires were used to collect close-ended quantitative electricity consumption data, such as appliance ownership statistics, usage and information on monthly electricity bills (see Appendix 4 for details of the questionnaire). Interviews and questionnaires were also combined with observation in the form of transect walks through the various spaces of the house, accompanied by photography. This allowed for more informal conversations and additional questions about the various house spaces, specific appliances and any other observations of interest. Interviews were originally conducted in 12 houses; however, homeowners from two of the households did not permit a guided tour of the house and photography and so, were excluded from the final sample. Details of the household and interview participant demographics are provided in Table 5 (also see Ch. 3, section 3.3 for further details). Efforts were made to ensure that the case-study sample was a good representative of varying socio-demographic characteristics embodied within the specified income group, representing a range of family structures, number of occupants, education level and age. Further, more women than men formed part of the interview sample. This was because the house is considered the domain of females in the Pakistani culture and since most household practices are performed by females, they could provide more informed answers to the interview questions.

In Chapter 4 (paper 2), research question 3 was answered through a mixed-method approach, including five case-study houses, oral history narratives from older residents of Lahore and a focus group discussion with seven middle-aged housewives. Details of case-study houses and interview participants are provided in Table 6 (also see Ch. 4, section 4.2.2 for further details). Fieldwork was carried out in the summer of 2017-2018 (see Appendix 1 for the fieldwork timeline). This was also when interviews with field experts in architecture and town-planning, history and social-sciences were conducted (which partly formed the sample for Ch. 6 (Paper 4)) and discussions pertaining to historical architectural evolution in Lahore overlapped with inquiries regarding professional design practices. The five case-study houses were chosen strategically to represent relevant housing typologies from different architectural periods in Lahore; also, houses were chosen that had been occupied by the same family for at least three generations to enable inquiry into how spaces, and their use, had adapted to changing needs over time. In addition to case-studies, oral histories from four

older residents of Lahore were also collected. For this, participants were selected strategically based on their age and familiarity with different areas and housing typologies in Lahore. The four selected participants were born and brought up in Lahore and had experience of living in different housing types during their lifetime. Two of the participants, born in late 1920s, had experienced living without an electricity connection in the house and provided rich narratives of how routine domestic chores and house spaces changed with electricity use over time. Similarly, the focus group discussion with middle-aged housewives provided insight into the changing use of house spaces with growing electricity demands over time. This was particularly useful in highlighting the cultural and social influences at play and the inter-generational differences in electricity use between homeowners.

In Chapter 5 (paper 3), the same set of interviews as in Ch. 3 (paper 1) were used to draw comparison with interviews from Danish households- conducted as part of a previous research project (see section 5.3 and The interviewed households in Denmark were primarily detached single-storey homes with single families, consistent with common family and housing structures in Denmark. Most households ended up being middle-class, dual-income families (only one family having parents younger than 30 years, as seen in Table 10), which reflects a demographic-based preference for investment in PVs. The interviews typically lasted for approx. 60 minutes and were conducted in Autumn 2016. All interviews were recorded, transcribed and later coded in NVivo.

Table 9 and 10 for further details of the research design and interview samples). For comparison, the authors initially held in-depth discussions on overall electricity consuming household practices in the two empirical cases, drawing out similarities and differences. During these discussions, it was discovered that laundering was the only practice being time-shifted that was common to both contexts. Following this, both sets of interviews were re-visited and re-analysed with specific focus on laundry practices and relevant themes identified in each case. Interim discussions during the analyses led to concretising the final themes for the comparison that best highlighted the critical aspects of demand response in each context.

In Chapter 6, an in-depth understanding of housing practices of various housing professionals in Lahore was formed through 17 semi-structured interviews with architects, town planners, builders and developers (for further details of interview participants, see Table 12 in section 6.2.2). Interviews were carried out in the summer of 2017-2018 (see Appendix 1 for the fieldwork timeline). The interview was designed to collect data on their general design practices, design philosophy, approach to energy reduction (if any) in design and how they navigated client demands. The interview structure was kept more open in this case, to account for the differences of foci between professions (such as those of designing, building and planning) and the more individual differences in knowledge of and engagement with low-energy/sustainable practices. Further, to form links between housing and household practices, two critical case-study houses were analysed to explore how low-energy

interventions in housing practices can lead to more sustainable household practices, mediated through the house design. The two case-studies were chosen strategically as representative of contemporary middle-class houses in Lahore that exhibit very different household practice-arrangement bundles. Details of case-study houses and homeowners' demographics are presented in Table 13 and 14. In addition to qualitative data collection through interviews and transect walks in case-study houses, quantitative data was also collected through time-use diaries and environmental data monitoring. Time-use diaries proved invaluable in generating spatio-temporal maps of household practice-arrangements, while temperature and humidity data was used to triangulate findings with qualitative data analysis from interviews. Environmental data was analysed using StataIC 15. The temperature and humidity data graphs were generated using Microsoft Excel, while the spatiotemporal mapping was done using CAD (Computer-Aided Design) software.

In all four empirical chapters, a comprehensive understanding of overall electricity demand was developed through analysis of household practices related to the following areas; comfort (including space cooling/heating and ventilation), lighting, cleanliness (including house cleaning and laundering), cooking (including food preparation, food storage and dining), and ICT/digital entertainment. In each specified area, the interview questions were framed to acquire information and gain insight into how electricity played a role in homeowners' routine practices, including the use and operation of appliances, responsibility allocations, seasonal variations and associated socio-cultural meanings and images, etc. (see Appendix 2 for the interview structure). Bathing practices were not included in the study, as these do not directly result in electricity consumption in the present case. The selection of practices was guided by the work of Gram-Hanssen (2008) with the aim of acquiring a holistic understanding of the household daily routines and practices that result in overall electricity consumption in households, hence negating the shortcomings of investigating practices in isolation.

All semi-structured interviews were audio recorded, translated from Urdu to English[3], and transcribed (see Appendix 5 for example of interview transcription). The analysis of the qualitative data was done using NVivo 11 (a type of CAQDAS- Computer Aided Qualitative Data Analysis Software). This facilitated the coding process by making it faster, more efficient, easier to visualise interlinks between different codes and providing structure and organisation to the analysis work (see Appendix 6 for an extract from the NVivo analysis). In the first instance, provisional codes were used to collect data (see Appendix 2), based on the research design. Once the interviews were transcribed and deductively coded, inductive coding was done in light of the research objectives. Following guidelines in Bazeley and Jackson (2013), Miles et al. (2014) and Saldana (2015), various stages of coding and recoding were done for progressive refinement of the codes generated, divided into two levels or cycles: In the

[3] Translation was a fairly straight-forward process. This is because English is a co-official language of Pakistan and is widely used in education, civil service and government departments. Its use is also quite prevalent in upper social circles. Hence, most interview participants responded to questions in a mix of Urdu and English.

first cycle of coding, an eclectic combination of attribute, structural, descriptive, in vivo, value, versus and holistic codes, etc were used. In the second cycle of coding, thematic codes were used to categorise the sub-level codes which were then peer-reviewed for elimination of researcher bias and validation. Finally, major themes were identified within the context of the research objective.

All interviews were designed and undertaken in accordance with guidelines provided by the Humanities and Social Sciences Research Ethics Committee based on the university's policy on research involving human participants and personal data. These guidelines are primarily drawn from the ESRC Framework for Research Ethics. The author also made use of online resources such as the *Ethical Guidelines for Good Research Practice* (by the Association of Social Anthropologists of the UK and the Commonwealth) and the *Code of Human Research Ethics* (by the British Psychological Society). Participants for the interviews were approached via email and telephone calls and told explicitly about the voluntary nature of participation. They were given time to reflect and decide on their participation accordingly. Clear information about the PhD research, underlying objectives, data use and their involvement were made clear both verbally and in writing (see Appendix 3). Conditions for anonymity and confidentiality were made clear to participants and informed consent was obtained before conducting interviews. One of the housing practitioners was willing to be interviewed but refused to be audio-recorded, and so the author kept notes during the interview. Interview participants were assigned pseudonyms, used during transcription and analysis. Audio recordings, consent forms and any personal or confidential information (such as electricity bills, etc.) were stored securely, under password protection. Due efforts were made during all stages of the fieldwork to abide by ethical principles of respect, competence, responsibility and integrity.

1.4. Limitations and methodological reflections

Whilst limitations of the various methods and data employed in the research in each of the empirical chapters have been identified and noted respectively in each paper, this section reflects on some of the general limitations of the theory, methods and research framework adopted.

Whilst practice theory presents a theoretical framework for analysing social order through the lens of social practices, critics of SPT have highlighted three key limitations in its theoretical application (Strengers and Maller, 2015). First, practice theories are limited to providing detailed accounts of everyday domestic life rather than understanding professional or other social domains. They have been critiqued for presenting limitations in accounting for macro-scale social phenomenon, specifically in conceptualising large-scale societal transitions. The present study addresses this critique by applying practice theory to the conceptualisation of housing practices of professional experts, including architects, planners and building developers (Chapter 6). By doing so, it demonstrates that practice theories are not limited to the analysis of micro-scale phenomenon, rather

they present a useful framework for highlighting links between micro-level household practices and the house building and urban planning processes at the macro-scale.

Secondly, whilst practice theories prove useful in explaining past practice trajectories in the reproduction and stability of practices, they are less suited to predicting, informing or guiding future practice performances for new and more sustainable configurations. According to Hargreaves et al. (2013), SPT is not well equipped to discuss the sources or emergence of novelty, as compared to other socio-technical transition theories such as the MLP, which allows the examination of the emergence of novel elements through the interactions between the vertically ordered levels of niche, regime, and landscape. It is true that practice theories have only recently been used in studies for designing interventions, and further progress in theory development is warranted. Efforts have been made in this dissertation to further this agenda, by applying practice theory in conjunction with concepts from STS to develop a sustainability intervention framework for housing and household practices in Pakistan (Chapter 6).

Finally, practice theories are perceived as lacking practicality in the implementation of standards and replicable programmes that are designed for sustainability interventions. In other words, they do not conform to dominant policy and change agendas, such as is the case for behaviour change models and frameworks. This may well be true since practice theories help conceptualise systemic change by challenging the existing status quo, rather than the small-scale incremental changes advocated by most individualist models. Practice theories help conceptualise other change agents and identify a range of other actants and stakeholders for improved sustainability by broadening the definition of intervention (Strengers and Maller, 2015). Whilst a range of change-agents and stakeholders were identified through the practice-based approach in this study (e.g. in Chapter 3, 4 and 6), further progress is needed in designing strategies and frameworks for practice-based interventions to become mainstream in housing and energy policy.

The research undertaken in this dissertation is primarily based on qualitative methods, including case-studies, in-depth semi-structured interviews, oral history narratives, transect walks and observation. Qualitative research is well-suited to an interpretivist ontology and social constructivist epistemology, that takes an inductive approach to the research design. Qualitative data provide a rich source of well-grounded and detailed descriptions of human processes. According to Miles et al. (2014), qualitative studies help to provide concrete, vivid, and meaningful explanation of events that help researchers to move beyond initial conceptions to more grounded inferential evidence. However, qualitative research is limited by its labour intensiveness, data overload, time demands of processing and coding and small sample sizes. It requires more vigorous research integrity since it is more open to the researcher's contextual interpretation of data and subjective bias. It also faces issues of generalisability of findings. Due to these limitations of qualitative research, no claims of

generalisability are made in this dissertation. Due to the contextual nature of the qualitative findings of electricity consumption in middle-class housing in Lahore, Pakistan, caution must be observed in the application of the results in other socio-economic groups or in other countries, since different climatic considerations, cultural norms, housing typologies and institutional systems in a different context would result in different socio-material framings, resulting in different forms of energy demand. However, although the empirical evidence might not be replicable, the theoretical knowledge contribution and the methodological framework design have broader applicability in different contexts and wider implications for research and policy more generally. Further, to overcome the limitations of qualitative data, efforts were made to ensure that a mixed method approach was used wherever possible, triangulating with various quantitative data sources to get a more comprehensive understanding of the subject matter.

One main tool for empirical data collection used in this dissertation was case-study research. The selection of case-studies was done on the basis of strategic and convenience sampling. Due to the small size and non-random selection of samples, case-studies are not representative, nor statistically generalisable to larger populations and different socio-economic groups. However, case-studies provide a good source of descriptive and explanatory insight and are most suited to developing theoretical propositions (Bent Flyvbjerg, 2006; Yin, 2014). Since the aim of the study was to expand understanding of the socio-material characteristics of household and housing energy demands and to explore the theoretical implications of applying practice theory to the socially differentiated context of Pakistan, the case-study approach provided useful insights to the research topic. Having said this, the dissertation study can be further enriched by additional future research that chooses different case-studies and even different socio-economic groups for comparison of domestic electricity consumption. The analysis of different case-study houses can lead to the emergence of different conceptual themes and analytical findings, furthering research in this field.

Empirical research in consumption studies from a practice theoretical perspective also presents certain methodological challenges. Halkier and Jensen (2011a) highlight two analytical affordances of practice theory in empirical consumption research; first, it helps to analyse consumption as entangled in networks of social reproduction and change. Secondly, it helps focus on the on-going relational nature of consumption in the intersections of multiple everyday practices. Nevertheless, how practices can actually be researched in practice, still remains under-researched and contested (Jonas et al., 2017). In empirical approaches to practice theory, but also within wider qualitative enquiry, preference is traditionally accorded to participant observation over interviews as method of data production (see e.g. Becker and Geer, 1957). This is based on the assumption that participant observation allegedly provides direct access to ‘doings’; actions and events of practitioners in the form of ‘lived experiences’ (Pink et al., 2013, p. 2), whereas interview data only provides access to accounts of action (Thompson, 1972; Halkier and Jensen, 2011a). Interview data is further perceived

as unreliable due to discrepancies between the 'doings' and 'sayings' of people and difficulty of interviewees in describing and explaining mundane, taken-for-granted everyday household routines and practices.

Refuting this stance, Atkinson and Coffey (2003) contend that research is a complex phenomenon which requires active reflexivity by the researcher to recognise their role as part of the social events and processes that are observed and narrated. The observing of events is not so simple, because events themselves pose complexities and difficulties in interpretation of what is being observed. Observed events are often retrospectively narrated by the researcher, hence open to the same cultural understandings of memory, account, narrative and experience as other methods like interviews. Alternatively, the authors propose that interviews are not 'just' narratives, but also a form of doing. This takes the constructivist approach that methods of data collection themselves form part of the knowledge produced. By presenting the concept of 'interviewing as action', the authors reject the limitations associated with interviews and transcend the strict dualism between "what people do" and "what people say they do". Hitchings (2012) also makes a similar claim that 'people can talk about their practices' in ways which are consistent with the theoretical basis of practice theory. Further, the act of interviewing can be used as a critical reflexive device by bringing actions into practitioners' consciousness and thus initiating positive change. Halkier (2017) argues against the positioning of observation as the 'gold standard' in qualitative research by advocating for multiplicity in that different research interests call for slightly different methodological research designs.

The selection of method also greatly depends on the type and setting of practices that are being studied. While participant observation can easily be accomplished for studying practices in public spaces, like working practices (e.g. Hargreaves, 2011), it becomes much more difficult, if not impossible, to study practices in private spaces, like households (e.g. see Higginson et al., 2014), as undertaken in this study. Due to the private nature of the house setting, household practices are generally studied through other methods, such as interviews (e.g. Southerton, 2006; Strengers, 2008; Bartiaux et al., 2014) or ethnographic interviews (e.g. Silverstone et al., 1991; Ho, 2015). However, to develop a more holistic understanding of household practices, other creative approaches can be used and are advocated for future research in this field. These include among others, auto-photography (e.g. Halkier, 2009), video recordings (e.g. Martens and Scott, 2017), energy and environmental monitoring (e.g. Bates et al., 2012; Foulds et al., 2013) and the more creative use of improvisation in a fictive performance of practices in a controlled setting (e.g. Kuijer et al., 2013). Hence, a comprehensive understanding of the lives of people can be achieved through a combination of methods.

While the choice of method is an important step in the research design, equally important is the identification of all relevant stakeholders. In the case-study houses, interviews were only conducted

with homeowners. During the interview process, it became evident that not all domestic practices were being conducted by the homeowners themselves, who often relied on house staff for daily household chores. However, interviews were not conducted with the house staff owing to certain practical limitations. First, the power dynamics between the homeowners and the house staff, and between the author as interviewer and house staff would have rendered it difficult to acquire unbiased information. It would not have been possible to interview the house staff independently of the homeowners, since most live in accommodation on site, and interviewing house staff beyond the case-study houses would have presented other difficulties of access. Secondly, most house staff in Lahore migrates from the surrounding rural areas where the common language is Punjabi, and not Urdu, further posing practical difficulties for the author in communication. Further, the 'doings' of house staff are strongly supervised and strictly monitored by homeowners in accordance with their instructions (for example, close proximity of the kitchen and laundering area ensures that homeowners can supervise house maids' laundry practices while they are undertaking cooking practices) and so, adequate information on the performance of household practices was gained from interviewing homeowners.

In the present study, to understand domestic energy demand, semi-structured interviews were initially conducted with homeowners. Analysis of household electricity consumption through a practice-theoretical lens brought to light the connections between household practices and the wider housing practices. Hence, interviews with professional experts in the housing sector were later included in the research design, including interviews with architects, town planners and builders. However, a more comprehensive understanding can be developed by including interviews with contractors, distributors and housing developers, etc., together with field investigation of the distribution networks and material supply chains. These represent important stakeholders and change-agents in the housing development process and future research in this area can provide greater depth to the analysis of domestic energy demand. Of the 17 interviews conducted with professional experts, only one was with a female participant- a town planner. No female architects and/or builders were included in the interview analysis. Whilst, in retrospect, a more even gender distribution could have been obtained through better care in sample selection, however it is also reflective of the male dominated fields of architectural practice and construction work in Pakistan. Such gender differences become even more prominent in top management positions. In selecting design, planning and construction firms strategically that emphasised low-energy/sustainable practices, the author did not find evidence of any female-led architectural/construction works in Lahore.

In the selection of method, since qualitative analysis is more open to the researcher's contextual interpretation of data and subjective bias, a combination of quantitative and qualitative data can prove extremely useful. Littig and Leitner (2017) argue in support of a mixed-method design for practice research. In their study of sustainable work and consumption practices in a cohousing community, the

authors reflect on the legibility of using a multi-method approach. While arguments against triangulation of quantitative and qualitative data rest on their differences in ontology and epistemology, the authors contend that both quantitative and qualitative data can take a positivist or interpretivist focus. As long as it is the methods and not methodologies that are mixed together, combining data provides advantages of a more detailed and diverse picture of everyday practices under study, as shown by Bates et al. (2012), Foulds et al. (2013) and Browne et al. (2014). Their research suggests that a combination of both quantitative and qualitative data can produce insights beyond those of non-integrated approaches. The research in this dissertation, therefore, combined various forms of qualitative and quantitative data in a mixed method approach to take advantage of the specific qualities inherent in each, while overcoming their individual limitations.

One of the key challenges in working with an interdisciplinary approach is not being able to delve into as much detail in each subject matter to be able to cover the breadth of concepts and theories. At times, the author felt out of depth not having the relevant background knowledge and context of the specific fields, such as in the sociology of consumption and STS approaches. Each disciplinary perspective also comes with its specialised nomenclature and set of terminologies which may be difficult to grasp by readers in other disciplines. The author initially struggled to grasp complex framings and critical concepts that required more detailed background research into some basic social science concepts, such as the inherent dualism between structure and agency that has been a point of debate among social scientists for decades. In this, working in collaboration with social scientists at the Danish Research Institute on the UserTEC project proved useful and provided a good learning experience. Fruitful discussions on theory and some of the basic concepts in the sociology of consumption provided the much-needed learning curve to develop enough understanding for empirical use. Though challenging, the interdisciplinary nature of the work helped to improve critical thinking, gain more self-awareness and provided greater confidence to tackle the various practical and theoretical challenges faced in answering the research questions. In retrospect, spending more time with relevant social scientists or taking a preliminary crash course in sociology might have provided much benefit and accelerated the process of learning.

An interpretivist and social constructivist approach to understanding household and housing practices and consequent energy demand was found to be liberating, providing freedom to focus on various aspects and generate specific themes in the qualitative analysis. However, it was also more prone to the researcher's personal biases in interpreting the data and in any discrepancies in the narration of respondents. From a practice perspective, the author, while researching practices, was also a carrier of existing household and housing practices. As a Pakistani female with a local architectural degree, living abroad and doing fieldwork in Pakistan as part of a foreign Western institution, the author had to navigate the various skills and understanding shaped both by local academic influences and foreign education, meanings shaped by the prevalent socio-cultural norms of the society to which the author

belonged and the perceived privilege and status attached with living abroad and being affiliated with a renowned university, and identity shaped by the conflicting positionality of being both an insider and outsider. Although such biases can exist in research and methods beyond practice theory, the enhanced reflexivity brought forth by practice theories in conceptualising, for example, notions of habitus, capital, historicity and prefiguration, etc. provided an additional layer of complexity. That said, the continuous questioning of the author's positionality in relation to the research work helped to develop a more incisive view of practices under study, take a more exploratory approach to existing socio-cultural norms and illuminate the taken-for-granted aspects of household and housing practices.

Further, due to the multiplicity of practice theories and their relatively recent development in the field of energy studies, throughout the dissertation the author questioned her understanding of the key concepts and whether its application in architectural design was being done the 'right' way. There are numerous, often contradictory and conflicting views from expert practice theorists about the theoretical and methodological application of the theory which make it difficult for those entering the 'practice theory circle' to make sense of. However, reflecting on these conflicts through an interpretivist and social constructivist approach entails that the empirical application of practice theory should itself be deeply contextualised according to the specific inquiry and area of research and its development a result of finding answers to the specific questions asked. Instead of reducing practice theory to a 'right' or 'wrong' process of application and/or methodology, the author discovered that focusing more on what kind of questions need to be asked and what socio-material norms need to be challenged in improving domestic energy demand provided much needed grounding for the research.

1.5. Thesis structure

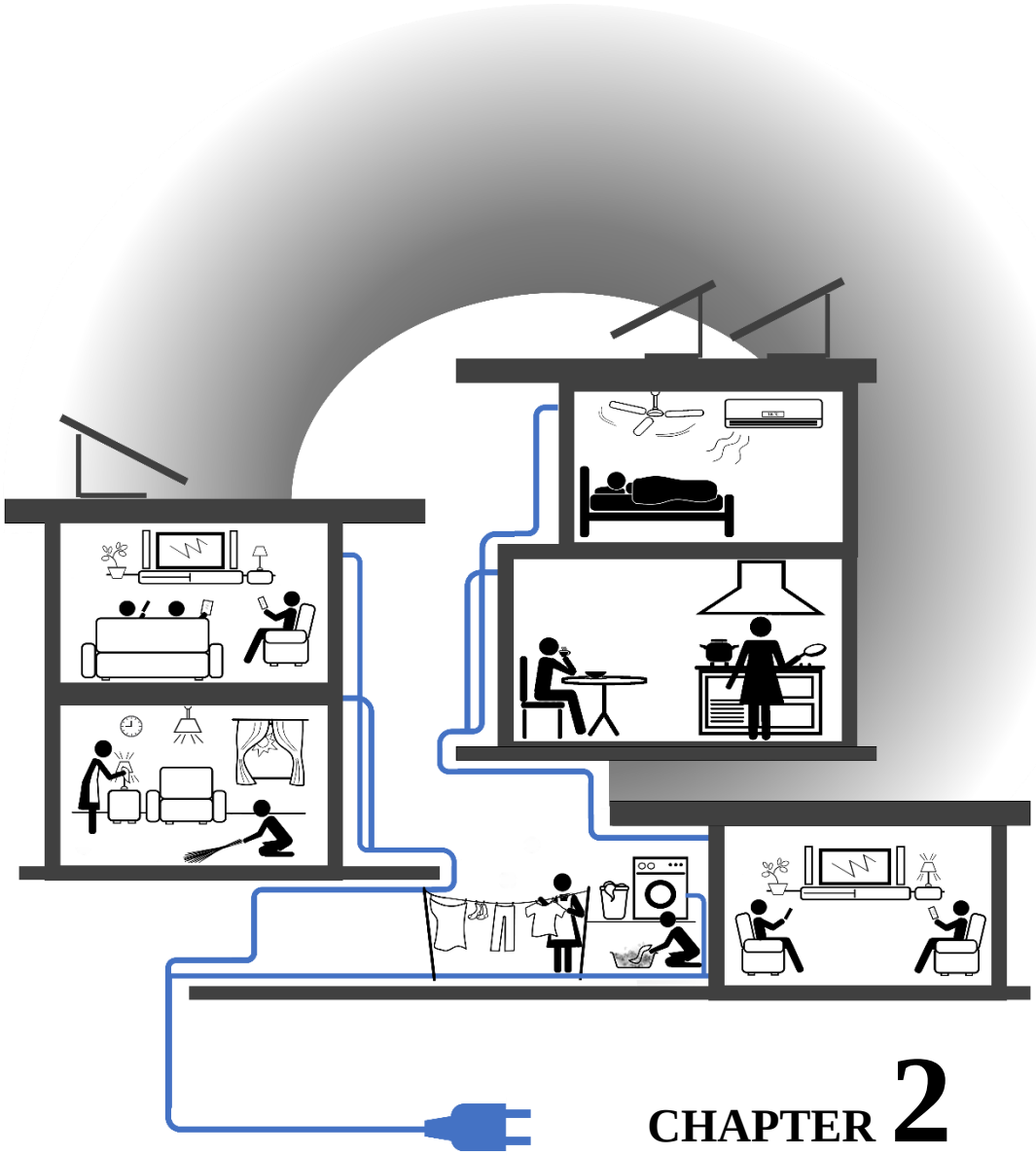
The dissertation is divided into three main parts. Part I presents the introduction and consists of two chapters. **Chapter 1** presents the introduction to the study, the need for a socio-technical approach to energy demand and background context of the study area. It lists the research aims and questions and presents a brief overview of the methods and scope of the study. **Chapter 2** outlines the literature review and the methodology adopted and frames it within the wider research on energy use.

Part II focuses on the first empirical section of the study and aims to answer the first main research question. It employs practice as a unit of analysis of household energy consumption and consists of three chapters. **Chapter 3** identifies the various socio-material characteristics of household electricity consumption in contemporary middle-class houses in Lahore. **Chapter 4** presents a longitudinal historical trajectory of household practices and house spatial layouts in Lahore to determine the co-evolution of household practice-arrangements and subsequent electricity demands. **Chapter 5** focuses on a cross-cultural comparative analysis of household electricity consumption in two

countries and their interlinks with the respective practice temporalities, materiality and socio-cultural contexts.

Part III presents the second empirical section of the dissertation that aims to answer the second main research question by employing practice as a unit of intervention in the design and use of houses. It consists of **Chapter 6**, which presents an investigation of architecture as a mediator of household practices. It goes on to explore the links between housing and household practices, mediated through the house design and how this can inform low-energy interventions in the design and use of middle-class houses in Lahore, Pakistan.

The dissertation concludes with **Chapter 7**, which summarises the main conclusions and findings of the research. It highlights the main theoretical and methodological contributions of the dissertation, the research and policy implications as well as scope for further study.



CHAPTER 2

2. Literature review

2.1. Theoretical approaches to energy use

While concepts of global warming and climate change put energy use at a macro-scale perspective, it is at the micro-meso level of individuals and households that the emanation of the domino effect of global change emerges. Household energy consumption plays a significant role in large-scale organisational and federal energy policies and helps in shaping energy transformations (Stern, 2014). A complete understanding of household energy consumption requires a detailed review of the following parameters (adapted from Janda, 2011; Ma et al., 2012);

- Physical parameters of the domestic buildings – Climate, orientation, building fabric and construction, structural materials, infiltration and physical arrangements
- Building systems – Energy supply sources, technologies, equipment and appliances
- Micro-generation – Solar PVs, solar heating, wind, etc
- Human factors – Occupant regimes, activities, access to controls, comfort requirements, energy consumption patterns, etc

Since the mid-seventies, research within these domains of household energy consumption has been the focus of study in various disciplines, each with its distinct theoretical orientations and research

methods (Lutzenhiser, 1992). With the goal of understanding consumption, improving efficiency, predicting future demands and designing policy frameworks, this literature has focused on energy use through its specific paradigmatic lens and empirical basis. A meta-analysis of this energy-use research (as undertaken by Lutzenhiser, 1992; Hitchcock, 1993; Wilson and Dowlatabadi, 2007; Moezzi and Lutzenhiser, 2010; Chatterton, 2011; Sovacool, 2014, among others) mainly categorises it into four broad disciplinary perspectives, as shown in Table 2.

The foremost focus has been on engineering/technology, with its dominant Physics-Technology-Economics Model (PTEM) (Moezzi and Lutzenhiser, 2010) to understanding energy demand and its efficient use. Here, research is focused on the first three parameters of household energy demand mentioned above, including physical and mechanical building systems, technology innovation and adoption, and future demand predictions based on energy simulations. In common practice, design and retrofitting of buildings is often based on static models or dynamic simulations and predicted thermal energy performance with assumptions or simplifications made in terms of building operations and use. In such models, the occupant is nothing more than a 'physiological system in a physical world' (Lutzenhiser, 1992, p. 50). While this approach has led to energy-efficiency innovations in construction, technologies and manufacturing processes, it has often led to technological determinism in energy and efficiency policies and 'spatial determinism' (Gans, 2002, p. 329) in architectural and design practice (see section 2.3.2 for further details). Various studies have proven that technological innovations and interventions per se do not lead to efficiency in household consumption (e.g. Darby, 2010; Crosbie and Baker, 2010; Strengers, 2013; Gram-Hanssen, 2014). Similarly, numerous studies reveal that estimates of energy consumption often vary widely from actual consumption, a variation defined as the 'performance gap' (Grubb, 1990; Menezes et al., 2012; Sunikka-Blank and Galvin, 2012; Palmer et al., 2016).

Studies show that on average, buildings can use up to three times more energy than their designed estimates (Palmer et al., 2016). Estimates also reveal that two-thirds of the variations in domestic electricity consumption remain unexplained even after discrepancies in standard socio-economic variables are accounted for (Gram-Hanssen, 2014a). In addition, improvements in building fabrics and thermal insulation can lead to 'rebound effects' (Khazzoom, 1980; Grubb, 1990; Saunders, 2000), thus resulting in ever-increasing demand. On the one hand, the PTEM model fails to capture the human factor that can account for how and why energy is actually used. Even in high-performance low-energy buildings, studies show that energy consumption can vary up to 1.5 times due to human factors (Gill et al., 2010). On the other hand, the understanding of technology as embedded in wider systems, where the development of technology is a 'social construction' (Gram-Hanssen, 2008, p. 1187) and in which '*technology is itself a political phenomenon*' (Winner, 1977, p. 323, emphasis in original) remains unexplored in such approaches. Further, studies show that current climate change

Table 2: Theoretical Approaches to Energy Studies. (Adapted from Chatterton, 2011; Moezzi and Lutzenhiser, 2010; Sovacool, 2014; Wilson and Dowlatabadi, 2007)

Disciplinary model	Approach to energy use			Main research method	Scale of analysis	Target for intervention
	Moezzi and Lutzenhiser (2010, p. 210)	Chatterton (2011, p. 7)	Wilson and Dowlatabadi (2007, p. 190)			
Economics (Conventional/ Behavioural)	*Price as the main signal (or incentive) to influence consumer action*	*Energy is a commodity and consumers will adapt usage in response to price signals*	*Utility maximization based on fixed and consistent preferences/ Widely varying decision heuristics*	Quantitative (observed behaviour/ controlled experiments)	Individualistic	Change or communicate Price-based decision frameworks. Provide info of benefits and incentives to improve cost-benefit ratio.
Psychology	*Individual expression through consumption choices: mental processes affect conservation behavior*	*Energy use can be affected by stimulus-response mechanisms and by engaging attention*	*Interacting Psychological and contextual variables*	Quantitative and Qualitative (surveys, observed behaviour)	Individualistic	Understand and influence individual attitudes, behaviour and choices through value-based incentives.
Engineering/Technology	*Characteristics of buildings and technology determine energy use, with focus on increased device and thermal efficiency*	***Educational** Energy use is a skill that is learned through experience in specific situations*	*Attitude-based evaluation of technologies and the consequences of adoption*	Quantitative (modelling and simulation)	Individualistic	Promote technological innovation and dissemination to segment population via regulation or appeals to market
Sociology/ Anthropology/ Social studies of technology	*Socially-negotiated patterns of consumption: focus on groups, cultures, and influences of larger social systems*	*Energy use is largely invisible, energy systems are complex, and daily practices are significant*	*Sociotechnical Construction of demand*	Qualitative and Quantitative (interviews, observation, surveys)	Collective/Social	Recognise social role of routine or habitual behaviour. Target people's life circumstances, identifying constraints and pathways for socio-technical regime change

and energy demand reduction targets cannot be met with technological efficiency alone (Ek and Söderholm, 2010; Pisello and Asdrubali, 2014; Sovacool, 2014).

Economic models are primarily concerned with the cost of energy to drive technological change based on principles of market supply and demand, using econometrics that factor drivers or constraints of price-response, such as fuel price, price elasticity and income (Hitchcock, 1993). The individual is at centre-stage in these models, but as a 'rational consumer' (Lutzenhiser, 1992, p. 51). Economic actors are assumed to make rational decisions, based on cost-to-benefit analyses with the intention of maximising utility and profits. Such models form the basis of energy feedback systems, home energy monitors, time-of-use tariffs, peak shifting and efficiency marketing strategies. However, such models are mostly devoid of the complex and often contradictory nature of human actions, black-boxing any number of uncertainties of demand into an economic 'rational' framework (Strengers, 2013). A good example is the failure of the UK Green Deal (an economic scheme to expedite energy efficiency retrofits and low-carbon heating in buildings in the UK) to yield substantial results. Putting aside the econometric flaws in its conception with high interest rates and increased supplier costs, the National Audit office reported that its 'design and implementation did not persuade householders that energy efficiency measures are worth paying for' (National Audit Office, 2016, p. 12). Another example is found in time-of-use tariffs, which are designed to financially incentivise people to use less energy during peak hours, but might not always work as intended (e.g. Torriti, 2014; Nicholls and Strengers, 2015; Friis and Christensen, 2016).

Psychology, in turn, provides the arguments for or against the economically driven direction for behavioural decision-making. It makes use of mental processes to determine individuals' perceptions, valuation processes, risk assessments, cognitive operations, personality structures, attitude systems, and norm internalisation to account for behaviour (Lutzenhiser, 1992). Collectively described as the ABC- attitude, behaviour and choice- models (Shove, 2010), psychological frameworks tend to rely on individuals' choice of pro-environmental behaviour in response to a set of externally-derived positive motivators and negative barriers, such as seen in the Rational Choice Theory (RCT) or the Theory of Planned Behaviour (TPB). This creates blind spots in conceptualising energy in relation to social structures and institutional contexts, cultural norms and habits, all of which can limit individual agency. Behaviour is simply the observable expression of social phenomenon which encompasses shared meanings, skills, and materiality and hence represents only 'the tip of the iceberg' (Spurling et al., 2013, p. 47) and limits policy intervention. Research even suggests that a focus on individual behaviour change actively detracts from other effective, large-scale sustainability transitions by closing off other possible conceptualisations of the causes of, and solutions to, environmental issues, to wider political concerns, relative power and conflicting interests of institutions and organisations (Shove, 1999, 2010; Dilley, 2015). One example of the use of psychological models is home energy feedback systems, where consumers are motivated to change their energy consumption behaviour

through information, awareness, comparison and economic and/or environmental incentives. However, various studies have shown that feedback fails to produce long-term effects (e.g. Hutton et al., 1986; Löfström and Palm, 2008; van Dam et al., 2010; Buchanan et al., 2015). Such limitations are often accounted to a 'value-action' gap (Shove, 2010, p. 1276) which serves as a proxy for the complex contextual factors, social norms and habitual processes that take place in everyday life and remain unaccounted for in such models.

Finally, sociology, anthropology and social studies of technology take a user-centered view of energy demand and focus on the broader perspective of understanding continuity and change in patterns of consumption, and interpretation of these patterns in relation to society, culture, history and technology (Moezzi and Lutzenhiser, 2010). Long-standing research in the social sciences demonstrates that differences in social class, ethnicity, age, gender, education, occupation, geographic location and cultural context result in variations in energy consumption, efficiency uptake and understandings of energy and technology (Lutzenhiser, 1992). Energy thus becomes an important ingredient in social organisation and societal transformation.

Whilst the various disciplines differ in their focus and understanding of energy-use, they also differ in their attribution of agency, both in terms of the basic unit of analysis and as the driver for change. The first three paradigms all focus on the individual as the dominant agency of choice, deliberate action and rational decision-making. This subsequently serves to set the tools for analytical techniques, data collection, and design of interventions in these models. Sociological models, on the other hand, take focus away from the individual to the normative social, institutional, material, and infrastructural contexts and structures that together interact and influence energy use (Chatterton, 2011). Instead of focusing on individualistic causal factors and external drivers, social theories focus on endogenous and emergent dynamics, reproduced through social practices (Shove, 2010). In this way 'consumption is not an exercise in individual choice but is a shared and collective activity that will be inconsistent and contradictory across time and space.' (Uzzell, 2010, p. 881)

In light of the limitations of the various disciplinary approaches to energy use, the importance of undertaking an inter/transdisciplinary approach in energy research and encompassing concepts and frameworks from social science has been contended by many scholars (e.g. Hitchcock, 1993; Schmidt and Weigt, 2015; Schweber and Leiringer, 2012; Winskel, 2014 among others). The need for energy research to be more 'problem-centered' instead of just 'technology-centered' is found to be intrinsic to future energy sustainability (Sovacool et al., 2015, p. 97). In particular, there is a need to integrate 'human-centered' research methods from the social sciences (Gram-Hanssen, 2013). According to Stern (2014), past experiences in energy related research provide evidence that single disciplines rarely provide the depth of knowledge of human-energy interactions essential to gain holistic understanding and influence change. As Strengers (2012) has highlighted, dominant paradigms

compartmentalise the energy responsibilities, such as the divide into energy supply and demand, with technological efficiency on one side and behavioural improvements on the other. Instead, social theories can help collapse this divide to examine how institutional and infrastructural systems of energy uphold or challenge existing norms, standards and needs in everyday household practices.

The socio-technical approach to understanding societal transitions has its roots in the interdisciplinary Science and Technology Studies (STS). STS is concerned with the understanding of the mutually constitutive relation between technology and society. The basic premise underlying STS approaches is that innovation and technological advancement, in and of itself, cannot bring about societal change, rather technology itself is a social, cultural and political construct (Shove, 1999). Socio-technical approaches include a broad range of analytical frameworks, including the Multi-Level Perspective (MLP) and the Actor Network theory (ANT).

The MLP (e.g. Geels, 2002) provides an analytical framework for understanding socio-technical change brought about by interacting processes between three successive heuristic levels: radical niche innovations, stable socio-technical regimes, and an external landscape. These represent the micro-, meso- and macro-levels of scale and stability. MLP is critiqued for placing technological innovation at its core, giving priority to producers in societal transitions than to final consumption and end-users (McMeekin and Southerton, 2012), in which the engagement with consumers and consumption remains underexamined (O'Neill et al., 2019). Further, the multiple levels of the MLP are argued to obscure the possibility of non-linear, sudden shifts, or dislocations, and significant changes within regimes even in the absence of landscape pressures (Schatzki, 2011; Shove et al., 2012).

A second theory prominent in the literature is the ANT (e.g. Latour, 2005). In ANT, the material is intertwined with the social, in which both humans and non-humans together form assemblies or networks of actants. Rejecting the notion of structural levels, ANT adopts a flat worldview (as opposed to MLPs multiple levels) where associations and subsequent networks between different *actants* (both humans and non-humans) form complex alignment processes that result in innovation. Larger-scale innovations and actions occur at sites that anchor multiple associations. (for further details of ANT in architecture, see section 2.3.2). However, ANT gives equal agency to both human and non-human actants. Social theorists critique ANT for its attribution of social action and social order to materiality and to its treatment of artefacts as 'immutable and relatively incorruptible transporters of power and influence' (Shove et al., 2012, p. 10).

To overcome some of the limitations of these analytical frameworks, practice theories focus on the continual, ongoing processes of reproduction and change occurring in forms of consumption through practices (McMeekin & Southerton, 2012). Social practice theory draws on Science and Tehcnology Studies (STS) in recognising and identifying the complex ways in which technology (and more

broadly materiality) is anchored in everyday practices, but that constitutes one among other elements of a practice, as explained in detail in the next section.

2.2. Social practice theory

Social Practice theory (SPT) forms the basic analytical and theoretical framework for the research undertaken in this dissertation. The four empirical chapters in this thesis draw on different conceptualisations from practice theories. This section will present a brief overview of practice theories, their position within social theories and their application in energy use studies.

Theories of practice emerged in the 1970s as a response to the fundamental contestations in social theory between the existing dualisms of action/structure, human/material and mind/body (Gherardi, 2012; Southerton, 2012). Prominent among its proponents (according to Schatzki, 2001) were philosophical practice thinkers Wittgenstein, Dreyfus, Taylor and Charles; social theorists Bourdieu and Giddens; cultural theorists Foucault and Lyotard; and those undertaking study of science and technology including Latour, Rouse and Pickering, among others. Reckwitz (2002a) presents a systemic ordering of classical social theories to establish the distinct position that practice theory holds in the sociological arena (Figure 2). Cultural theories, of which practice theories are a part, are framed on the core principles of structuralism that distinguish these sets of theories from the previous two (purpose-oriented and norm-oriented forms of social action) in their perceptions of human action and social order. Instead of utter dependence on individualistic expressions or absolute compliance of collective normative expectations, cultural theories take an intermediary approach; conceptualising actions within the symbolic structuring of 'shared knowledge' (Reckwitz, 2002a, p. 246). According to Schatzki (2001), it is the distinctive 'attribution of order to practice nexuses' (2001, p. 14) that differentiates practice theory from the prior two schools of thought.

Practice theories provide an integrated framework to conceptualise a duality of social structuring: structures condition human activity, which through their recursive reproduction through practices, reconstitute these very structures (Giddens, 1984b). According to Giddens (1984a), the structure of social order is composed of sets of rules and resources. 'Rules' are 'procedures of action' that are recursively implicated in the practical activities of daily life. Resources, both allocative (material and economic resources) and authoritative (capacity to persuade) are the medium through which social power is exercised. In this social ordering, practices are the site where 'understanding is structured and intelligibility articulated' (Schatzki, 1996, p. 12). Bourdieu (1977), in outlining a theory of practice, provides an understanding of practices in the context of the individuals inherent disposition, 'habitus', defined as 'systems of durable, transposable dispositions, structured structures, predisposed to function as structuring structures' (1997, p.72), available means or resources, 'capital', and the social arena, defined as the 'field'. For Bourdieu, social differentiation of practices is a key theme. In addition to dispositions formed by past experiences, individuals draw upon socio-economic and

cultural resources, demarcated as 'capital'. The various forms of capital are both embodied and objectified in individuals' pursuit of class distinction and desirable social standing and together, these play a central role in defining their positioning and performance of practices in the social world. Bourdieu (1984, p. 101) formulates practice as;

[(habitus) (capital)] + field = practice

Practices produced by the inter-related habitus, capital and field are the 'strategy-generating principle enabling agents to cope with unforeseen and ever-changing situations.' (1977, p. 72). However, Bourdieu's notion of cultural capital and socioeconomic factors, and how these influence the formation of practical consciousness, have not formed part of contemporary versions of practice theory in energy research, which primarily developed and gained momentum in a Western context.

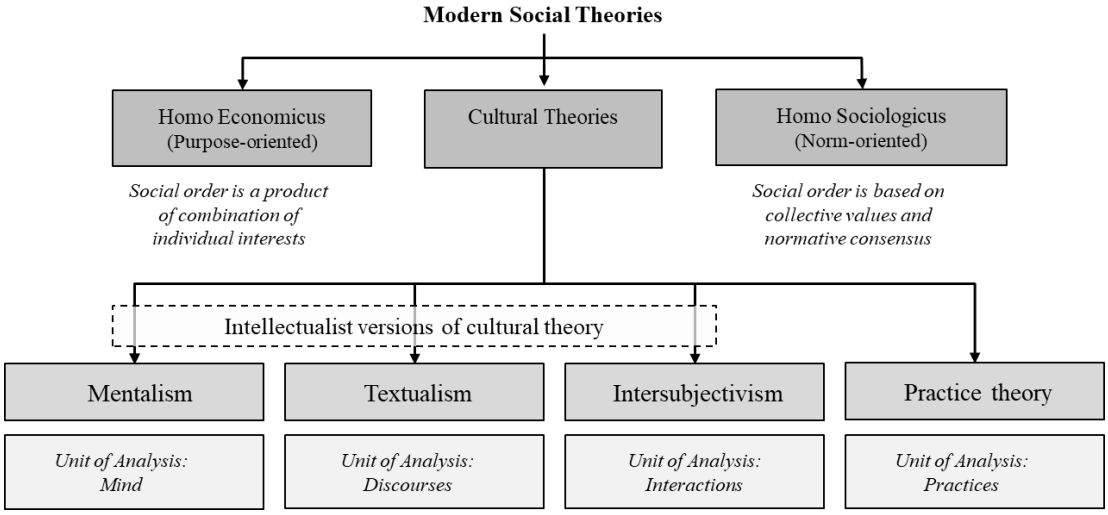


Figure 2: The position of Practice theory within Social theories. Source: adapted from Reckwitz (2002)

Table 3: Comparison of the theoretical framing of individualistic models versus Practice theories. (Adapted from Strengers, 2012, p. 102; Warde, 2014, p. 75)

Individualist models	Practice theories
Focus on individuals	Focus on practices
Individuals and their drivers, barriers, attitudes, values, opinions, choices and/or norms as basic unit of analysis	Practice (and their elements) as basic unit of analysis
Action	Habit and routine
Mental, discursive or symbolic representation	Material, embodied or practical consciousness
Rational thinking and reasoning	Doings and sayings
Individual motivation and preferences	Shared understandings and collective norms
Individual acts are taken in isolation	Practices are in constant flow
Change is orderly, predictable and controllable	Change is emergent, dynamic and often uncontrollable
Change through targeted information, awareness, education, price signals and technological efficiency	Change through breaking or forming of new links between practice elements, practice bundles and practices and material arrangements

In 2001, the rhetorical announcement of a 'practice turn' (Schatzki et al., 2001) in contemporary social theory instigated the next phase in the development of practice theories. Practices came to be understood as the 'temporally unfolding and spatially dispersed nexus of doings and sayings' (Schatzki, 1996, p. 89) that formed the basic unit of social analysis and provided an analytical framework for empirical social science. Contemporary practice theories not only present an alternative approach to the understanding of social phenomenon, they provide a framework better suited to the comprehension of and intervention in the dynamic processes of societal transformation (Shove, 2010). Instead of focusing on individual motivations, attitudes and choices as barriers to social change (Table 3), practice theories provide insight into the shared understandings, social practices and their inherent links and elements as the focal of societal transition. In this way, social change transforms from an obscure, abstract uncertainty into a more concrete, feasible reality;

> '…analytic focus shifts from the insatiable wants of the human animal to the instituted conventions of collective culture, from personal expression to social competence, from mildly constrained choice to disciplined participation.' (Warde, 2005, p. 146)

2.2.1. Definition and elements of practice

The contemporary notions of 'practice theory' and 'practices' have several different meanings in social science but their use in energy research is primarily based on Schatzki (1996; 2001) and Reckwitz (2002a, 2002b) whose work has been introduced to energy studies by Warde (2005) and Shove et al. (2007, 2009, 2012) and applied and elaborated on by researchers like Gram-Hanssen (2008, 2014a).

Contrary to Giddens, Schatzki (1997, 2002) sees habituated skills, practices, instead of 'rule'-following, as an explanation of human actions. Schatzki (1996) understands practice as a spatially and temporally coordinated entity central to any analysis of human existence. Alternatively, Reckwitz defines practice as;

> 'a routinized type of behaviour which consists of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge.' (Reckwitz, 2002a, p. 249)

The past two decades have seen varying concepts and frameworks of SPT, in particular the constituent elements that together form a practice, defined by authors of diverse disciplines (see Table 4 for a summary of these definitions). Although similarities exist within the frameworks of different authors, the crucial distinction in perceptions lies in the positioning of the material entities.

Materiality is largely absent in Schatzki's theory of practice. For Schatzki, materiality lies outside the realm of practice as 'the medium through which a capacity is exercised cannot itself be a capability' (Schatzki, 1996, p. 145). Rather, it is at the 'sites of the social' where the practice-(material) arrangement nexuses central to human co-existence exist (Schatzki, 2010a; see section 2.3.1 for further details of Schatzki's conceptualisation of practice-arrangement bundles). For Schatzki, practices are organised through three dimensions: practical understanding, explicit rules and teleoaffectivity (a fourth dimension of general understandings was later added to his schema). Reckwitz (2002b) and Warde (2005), on the other hand, puts 'things' and 'items of consumption' squarely as necessary components of practices. They signify the importance of materiality in cultural theories in that objects enable and limit certain bodily and mental activities and, as they are handled and re-handled continuously, endure the limitations of time and space thus ensuring that social reproduction does so as well. So, the relationship between human agents and non-human entities in the practice nexuses co-constitutes social order.

Table 4: Key elements in practice theory as presented by different social scientists. Source: adapted and modified from (Gram-Hanssen, 2011)

Schatzki (2002)	**Reckwitz (2002a)**	**Warde (2005)**	**Shove-Pantzar (2005)**	**Gram-Hanssen (2011)**
Practical Understanding	Body Mind The Agent Structure/Process (routine)	Understandings	Skills (Competences)	Know-how & embodied habits
Rules	Knowledge Discourse/	Procedures		Institutionalised knowledge & explicit rules
Teleo-affective structures General understandings	Language	Engagements	Images (Meanings)	Engagements
	Things	Items of Consumption	Stuff (Products)	Technologies

Gram-Hanssen (2011) focuses on technology as the material constituent of practices in societal transitions. The author argues that the cultivation and naturalisation of habits (as seen in the process of domestication of technologies), and thus change of practices depends on the combined elements of technological setup, social organisations, along with the elements of know-how and engagement. Shove et al. (2012) and Shove and Pantzar (2005) adopt a wider definition and consider materiality as an all-encompassing whole. Their conceptualisation presents practices as the interconnected relations between three elements: materials (including objects, infrastructures, built environments, tools, hardware and the body itself), meanings (representing the ethos, norms, aspirations, ideologies, symbolic significance, perceptions and the reasoning in carrying out practices) and competences (understanding, know-how, the learnt bodily and mental routines).

The various frameworks for practices and their constitutive elements provide a useful analytical tool as a heuristic for understanding how a society works. According to Pantzar and Shove (2010),

practices and the relationships between them co-constitute the renewal and transformation of elements, which through their specific integrations, produce, reproduce and transform practices and the wider systems of practice.. Warde (2005) asserts that practices are internally differentiated as the practitioners in different situations carry out the same practice differently. In addition, the individual acts as the 'intersection point' (2005, p. 144) of many different practices. Hence, the study of single practices negates the significance of the connections, conjunctions, alliances and conflicts that exist between simultaneously occurring or existing practices (Warde, 2005; Hargreaves, 2011). Study of such bundles of loosely knit or complexes of more tightly knit practices (Shove et al., 2012) highlight the interlinking nature of everyday practices.

The relationship between practices and performances is recursive; practices configure performances, and practices are reproduced and stabilised, adapted and innovated, through performances (Southerton, 2012). The routine nature of practices is important in that action regularities in daily life come from 'repeated observance' (Schatzki, 1996, p. 145). Routines are both built by and contribute to the preservation and continuance of the social and cultural structures of society (Gram-Hanssen, 2008). For a practice to persist and maintain its identity, it must be continually reproduced by its doers (Shove and Pantzar, 2005).

2.2.2. Practice and energy use

As practice theories gained momentum in contemporary social theory, the sociology of consumption shifted focus from the 'symbolic' to the 'routine' and 'habitual' character of consumption (e.g. Gronow and Warde, 2001) in that most everyday practices require and entail consumption (Warde, 2005). This was a call for improved understanding of energy consumption in terms of a consequence of the social dynamics and temporalities of everyday practices for improved efficiency, optimal demand response, greater sustainability and more impactful policy interventions (Shove and Walker, 2014; Walker, 2014). Warde (2005) and Shove et al. (2015) argue that energy consumption is inherently an outcome of social practices. Warde states that 'consumption is not itself a practice but is, rather, a moment in almost every practice' (2005, p. 137). He further clarifies that people 'consume' without registering or reflecting on it, and only as a consequence of employing certain other practices like cooking. In this way, the daily life of the contemporary individual can be seen as a complex network of interwoven patterns defining interplays of energy and practices.

To date, practice theories have been widely used in empirical studies of everyday routines and practices in shaping energy demand in Western countries. They have been used extensively in the study of consumption related to individual household practices of comfort (e.g. Shove, 2003; Strengers and Maller, 2011; Macrorie, 2012; Walker et al., 2014), cleanliness (e.g. Hand et al., 2005; Kuijer et al., 2013; Higginson et al., 2014), cooking (Shove and Southerton, 2000; Halkier, 2009; Halkier and Jensen, 2011b; de Jong et al., 2013) and ICT (Ropke et al., 2007; Ropke and Christensen,

2013). Theories of practice have also been used to examine domestic DIY activities (e.g. Watson and Shove, 2008; Maller et al., 2012; Karvonen, 2013) and professional retrofit practices (e.g. Bartiaux et al., 2014; Judson and Maller, 2014; Palm and Reindl, 2016). Further, a practice perspective has been applied to the analysis of peak energy demands (e.g. Strengers, 2012; Powells et al., 2014; Nicholls and Strengers, 2015) and smart technological interventions (e.g. Darby, 2010; Strengers, 2013; Gram-Hanssen and Darby, 2018).

In addition, the analysis of domestic energy demand through study of the trajectories of material infrastructures and patterns of accompanying social practices has been well underway in Western countries. Kuijer and Watson (2017) have presented a trajectory of housing circumstances, heating provisions and patterns of everyday practices in UK for better policy implications. Hand et al. (2007) have explored how the coevolution of technologies and practices enforce new demands on domestic spaces, influencing experiences of spaces and the meanings associated with specific configurations. Rinkinen and Jalas (2017) have used Schatzki's notion of 'prefiguration' to explore how the house design and configuration can order and prefigure certain practices like those of heating and comfort-related practices by embedding them in material and spatial arrangements of the house itself. Strengers and Maller (2011) highlight how contradictory health, housing and energy policies have conflicting influences and normalising effects on air-conditioning for space cooling in Australian houses.

On the other hand, studies that analyse the interlinks between practices and materiality in a non-Western context are limited. Of the few exceptions, a study of societal transformation in light of household consumption has been explored in the state of Kerala in southern India by Wilhite (2008a). The analysis reveals how the changing social, material and discursive context has resulted in increased use of household goods and commodities, consequently increasing energy consumption. Sahakian (2014) has presented a review of electricity transitions for residential cooling in Southeast Asia's mega cities. Her analysis reveals the importance of housing architecture and associated ideals of 'good life' in the Philippines in rising trends of electricity consumption. Taking the case of a rural village in Thailand, Smits (2011) has explored energy transitions in Southeast Asia from a socio-technical standpoint, highlighting how the energy trajectory is shaped by the local socio-political and spatial context. Using a practice-based framework, the influence of socio-material structures on energy consumption in Singaporean households has been undertaken by Ho (2015). Through ethnographic interviews, the author provides evidence of how material path-dependencies, ethical complexities and social histories shape practice formations that remain unquestioned in green policies and contradict state objectives of continued economic growth and technological advancement. A practice-based analysis of the histories, trajectories and patterns of water using practices in China has been presented by Brown (2016). Through her research, the author advocates for the development of nuanced,

regionally bound conceptualisations of practices and social changes in the Global South for improved sustainability.

Further, while focus on energy demand management through understanding of practices and their spatiotemporal arrangements and flexibility has formed the basis of empirical work in many single case-studies (Strengers, 2012, 2013; Powells et al., 2014; Higginson et al., 2014; Nicholls and Strengers, 2015; Friis and Christensen, 2016). Practice-based comparisons that analyse cross-cultural diversities in energy consumption and everyday practices are limited. Some exceptions include the study of practices related to eating (Durand-Daubin and Anderson, 2018), refrigerating/freezing (Rinkinen et al., 2017), reading (Southerton et al., 2012), comfort (Hansen et al., 2016; Heidenstrøm et al., 2013), and energy retrofitting (Bartiaux et al., 2014). There are very few examples of comparative studies between countries in the West and East or in the Global North and South. Among these is Wilhite et al.'s (1996) cross-cultural study of Japan and Norway which juxtaposes similar material culture profiles in differing cultural contexts and exemplifies how certain household practices are more firmly bound by local traditions and conventions than others. Cultural diversity in bathing practices in the Netherlands, India and Japan has been the focus of Matsuhashi et al. (2009) who posit the importance of understanding variety in practice performances for improved sustainability in design.

2.3. Connecting the social and the spatial

This thesis helps bring together some concepts from the two parallel streams of social theory and the sociology of architecture, which have, at different moments in time, converged and diverged in their exploration of the social and the spatial and the resulting socio-spatial interactions. This section starts with an account of the spatial in social practices and follows on with how the social is encountered in architectural discourse, highlighting gaps in existing literature, followed by an account of how these gaps are addressed in the present study.

2.3.1. Space in social practices

It was in the late twentieth century that social relations and spatial structures, studied as distinctly separate fields in the past, were brought together by theories of structuration (Gregory and Urry, 1985). Spatial structure was thought of as not merely the arena for the unfolding of social life but 'as a medium through which social relations are produced and reproduced' (1985, p.3). Both time and space were considered central to social theory and thus of considerable importance in empirical social research. At the turn of the century, sociologists and social theorists argued for 'a space for place in sociology' (Gieryn, 2000). This 'spatial turn' in contemporary social theory has called for a reassertion of space in the analysis of social order, as it shapes and is, in turn, shaped by social action (Fuller and Löw, 2017). Instead of conceptualising space as a neutral background for human activity,

this literature advocates for space to be considered in relational terms, where ‘the social is spatial, and vice versa’ (Fuller and Löw, 2017, p. 469) and where space is made meaningful in providing order to the social world (for a discussion of the spatial turn in social theory, see e.g. Gieryn, 2000; Gans, 2002; Thrift, 2006; Peters and Kessl, 2009; Löw, 2013; Blank and Rosen-Zvi, 2010).

Giddens, renowned for his theory of structuration and among the pioneers of practice theories, posited a context-dependent study of socio-spatial arrangements as fundamental to all social analyses. According to Giddens:

> ‘All social life occurs in, and is constituted by, intersections of presence or absence in the ‘fading away’ of time and the ‘shading off’ of space.’ (Giddens, 1985, p. 283)

For Giddens, the amount of time-space available to an individual in a day forms the bounds that define social practices. He explained the relation between social-system integration using concepts of locale and regionalisation. According to Giddens, locales, unlike place, cannot be defined only in terms of the physical structures but are also internally regionalised by creating contexts of interaction and are integrally involved with the structural constitution of social systems. As such, they are responsible for the ‘fixity’ (1985, p. 271) underlying institutions. Regionilastion is not just localisation in space, but the zoning of time-space in relation to routinised social practices. In this, context is the bridge that links the intimate and detailed components of interaction with the broader institutionalisation of social life:

> ‘To study the structural principles involved in the reproduction of a society across time-space is to analyse the modes of differentiation and articulation of the institutions which constitute that society. Structural principles are principles of organisation implicated in those practices most 'deeply' (in time) and 'pervasively' (in space) sedimented in a society. It is on this level that we have to analyse the 'base/superstructure' problem as a historical, rather than ontological, feature of the 'materialist conception of history'. (Giddens, 1981, pp. 54–55)

This conception of social-system integration can be applied to the spatial context of a house as a locale, which is regionalised into various space-time zones. Most routinised social practices, because of their recurring nature, can thus be represented as reversible trajectories of timespaces that are regionalised in loop forms within the house as a locale, which provides the context of interaction of homeowners. Such locales as depicted by the urban fabric of the built environment form an infrastructure of social life. Indeed, as described by Miller (2001, p. 4), the home is both ‘the source and the setting of mobility and change’.

According to Gieryn (2002), the duality of structure and agency in the built environment is integral to the interdependent transformation of places and societies. He argues that this inherent dualism can only be understood in its entirety by taking a combined account of Giddens' and Bourdieu's theorisation. Both acknowledge the significance of the built environment in relation to social order. Giddens highlights the significance of material spaces in that 'the contextuality of time-space, and especially the connections between time-space location and physical milieux of action, are not just uninteresting boundaries of social life, but inherently involved in its constitution or reproduction.' (1984, p. 126–127). However, Giddens attributes a higher agency to individuals than to spaces in that 'location is only socially relevant—and this is crucial—when filtered through the frames of reference that orient individuals' conduct' (Giddens, 1993, p. xv). On the contrary, Bourdieu accords a higher degree of agency to the built environment that structures social practices and dictates cultural distinctions. In this regard, most famous is his earliest empirical interpretation of the spatial layout of the Kabyle House as structuring and reproducing gendered practices in Berber society (Bourdieu, 1970). It is only by combining the two narratives that a full account of the duality of the built environment is brought forth as a structuring agency that can be restructured by human agency. According to Schatzki , social life consists of not only objective space and objective time, but also of what the author refers to as 'timespace', an element crucial to the existence of society. The time component of activity timespace is taken from Heidegger's 'temporality' which is the future-present-past dimensionality of human activity. Each an essential dimension of activity, the past, present and future are taken to be simultaneous. The spatial dimension of timespace can be referred to as 'phenomenological', 'existential' or 'lived' space. Taken from the concept of Heidegger's 'spatiality', it consists of arrays of paths and places which are anchored in material entities amid which activity takes place. These arrays are called settings, which in turn form broader locales and regimes. Schatzki's theory of the temporality and spatiality of human activity is grounded in teleology and motivation:

> 'The future dimension of activity is acting for an end, whereas its past dimension is acting because of something. The future is teleology and the past motivation. The present is acting itself. The temporality of activity is, thus, motivatedly acting teleologically.' (2009, p. 38).

Timespace is thus fundamental to social order. Social life amalgamates activity timespace and objective space-time. Interwoven activity timespaces form the infrastructure that pervades the practice-arrangement plenum, which in turn coordinates and aggregates all human activity. In Schatzki's (2010a) practice theory, social order or the site of the social transpires as part of 'nexuses' of practices and material arrangements. The term 'nexus' here refers to the series of connections or links that form chains of action through which people's lives 'hang together'. Such chains of action represent moments of practices that are inherently tied to various forms of material arrangements.

Material arrangements refer to the set of interconnected material entities which can include humans, artifacts, organisms, and things of nature. The bundling of practices and material arrangements occurs in that (1) practices effect, alter, use, give meaning to and are inseparable from arrangements while (2) arrangements channel, prefigure, and facilitate practices (Schatzki, 2011). Material arrangements help to anchor the places and paths where practices occur. From a practice-based perspective, physical configuration of the house presents one such example of material spatial arrangements that reflect context-specific temporal and ideological structuring of various household practices (Hand et al., 2007). The imaginaries of values and expectations of home and daily life are given form through the house that acts as a coordinative and coordinated aggregate (Rinkinen and Jalas, 2017). The history of domestic architecture provides evidence of how homes can have emergent consequences for the trajectories of practice nexuses (Shove et al., 2012).

According to Schatzki (2010a), nexuses of practices and material arrangements, in turn, link to wider nets of nexuses that then compose larger social institutions, like governments, financial networks and urban planning and development, etc. At another instance, Schatzki (2011) refers to such large social phenomena as 'bundles of practices and material arrangements, more specifically, as constellations of such bundles or of slices or features thereof', where constellations of bundles represent 'larger bundles'. This points to the understanding that all social phenomenon, whether macro/global or micro, at its core is formed of the same composition of practice-arrangement bundles. Schatzki follows on to describe the sum of such bundles as 'the plenum in which all social affairs transpire' (2011, p. 4). In this way, social phenomena consist of some slice or aspect of the plenum of practice-arrangement bundles. One key feature of this plenum important to the discussion in this thesis is the emergence, persistence and dissolution of bundles.

The emergence of a practice-arrangement bundle first entails the coalescence of the practice, as a combination of the necessary elements that form the practice. New practices do not require new arrangements and can coalesce amid existing ones. This emergence also entails production and introduction of specific material entities and arrangements. A bundle persists when the changes it undergoes are limited, cumulative, and occur amid general continuity in its components; meaning the changes it faces are neither too frequent, nor too large. Otherwise, under pervasive or massive changes, the bundle dissolves or seizes to exist and is replaced by a new bundle. As an example, a new household practice-arrangement bundle can emerge when there are critical changes in the built environment. Changes in existing practices can be inevitable to adjustments to such new settings, thus resulting in changing existing bundles. Similarly, new bundles are formed with material innovation (such as the advent of televisions and air-conditioning) or intentional redesign of built environments (such as the obsoletion of central courtyards) to accommodate changing practices (such as changing norms for keeping cooling). As posited by Schatzki, 'the emergence of practice-arrangement bundles

embraces changed practices, changed arrangements, or altered links between practices and arrangements' .

2.3.2. The social in Architecture

At a time when the significance of space was gaining momentum in contemporary social theory, the traditionally spatial disciplines of architecture and urban studies on the other side of the spectrum were also facing a period of transition- that of an increased awareness for the social in the built environment. During the late 20th century, a call was made for greater engagement of architecture with social theory for understanding the complexity and agency of the built environment (e.g. Dutton and Mann, 1996; Hatch, 1984; Knox, 1987). In articulating a 'theory of social architecture' (Hatch, 1984, p. 3), this literature questioned the existing ideological representations in the architectural profession at the time; focus had either centred on accounts of autonomous individual artistry (e.g. McNeill, 2006; Imrie and Street, 2014) with architects considered as 'artistic form-givers' (Lorne, 2017, p. 268), or on spatial determinist paradigms that attributed social change to a simple and linear process of spatial redesign (Gans, 2002). Absent from this professional discourse were discussions on the interconnections and interrelations between architecture and the economic, political and social concerns of society (e.g. Crawford, 1991; Ward, 1996).

The turn of the century saw further movement in the sociology of architecture to reformulate the role of architecture in society and reconceptualise architecture's capacity for progressive social transformation (Dutton and Mann, 1996). This was a movement towards spatial design and processes that prioritised socio-economic and cultural objectives (Till and Schneider, 2012; Müller and Reichmann, 2015; Lorne, 2017) in which 'the making of architecture is a social practice' (Dutton and Mann, 1996, p. 1). Mumtaz (1999) claimed that the transformative and communicative quality of architecture entails its interactive participation in the dynamics of social change:

> '…architecture becomes a prime mover in the dynamics of culture and society: It reinforces the social fabric when it manifests aspirations which are attainable; when it reflects images of the self which are truthful; expresses values which are noble; and concretizes identities which are real. But it corrupts the social fabric when it manifests aspirations which are impossible; reflects images of the self which are illusions; expresses values which are base; and concretizes identities which are false' (Mumtaz, 1999, p. 52)

According to Pramar (2005), an analysis of the sociology of architecture would remain incomplete without realisation of the social and cultural traditions that determine 'the kind of architecture that arises and the functions that it has to fulfil' (2005, p. 7). Thus, the link between society and

architecture was deemed critical in understanding the evolution and transformation of society, particularly in determining potential pathways to sustainable transitions.

Despite the advocacy for a 'social architecture' (Ward, 1996) since the late 1980s, there still exists a need for socially progressive architecture (Lorne, 2017) in contemporary architectural practices that introduces new conceptualisations of spatial agency (e.g. Awan et al., 2011; Till and Schneider, 2012) and represents stronger ethical and moral engagement with society (McNeill, 2006; Chan, 2015). As a response, alternative architectural frameworks, such as user-centred design have recently gained popularity (e.g. Sanoff, 2007; Harboe, 2012; see the seminal work of Norman, 2002 on user-centred design). However, while such frameworks provide a much needed shift away from architects as the carriers of individual agency in building formation to the occupants as users of those buildings, critics have highlighted how they often take conventional needs for granted, reproducing high demands and maintaining the unsustainable status quo (Redström, 2006; Shove et al., 2007; Scott et al., 2012).

Spatial determinism makes claims of a causal relationship between architect's agency for (re)design and change in social behaviour, denying any non-linear, mutual interaction between spaces and social action. On the contrary, the concept of spatial agency, as proposed by Awan et al. (2011a) draws on Giddens (1984) duality of structure and agency and Lefebvre's (1992) social production of space. Instead of attributing architects the sole agency of defining spaces, spatial agency acknowledges the dynamic and temporal nature of space in that spatial production is part of an evolving sequence to which multiple actors contribute at various stages. Hence, in overcoming the divide of structure and agency, Awan et al. (2011) contend that architecture is not seen as determinant of society, nor as determined by society, but rather as *in* society:

> 'Spatial agency implies that action to engage transformatively with structure is possible, but will only be effective if one is alert to the constraints and opportunities that the structure presents.' (Awan et al., 2011b, p. 31)

This then allows agents the capacity to intervene in the spatial but also to refrain from intervention when this might be deemed more influential under certain circumstances. The authors thus play on the idea of 'non-building' as a form of intervention and practicing architecture in ways that go 'beyond simply building'. According to the authors, instead of adding and building more, architects should focus on addressing spatial problems with alternative spatial solutions (Till and Schneider, 2012).

In a similar vein, the idea of moving beyond simple efficiency to *sufficiency* in buildings for reduced energy use and emissions has recently been proposed in the building and energy policy literature. Bierwirth and Thomas's (2015) conceptualisation of a 'building typology of sufficiency' looks at reducing/optimising floor space use in buildings. According to the authors, sufficiency through floor

space reduction in building design and use can be accomplished in three ways: 1) building less to support more low-energy lifestyles, such as tiny houses or virtual workspaces; 2) building flexibly to allow multifunctionality, such as through extendible units and movable walls; and 3) building shared spaces such as community areas or spaces for interim use. However, Bierwirth and Thomas's (2015) concept of building sufficiency distinguishes between building design and use, unlike socio-technical theories that provide an integrated framework to overcome the duality of structure and agency.

Recently, socio-technical theories have become popular in architectural design in conceptualising agency of the built environment in shaping social change through relationality (e.g. see Fallan, 2008; Latour and Yaneva, 2008; Yaneva, 2009 for an ANT approach and Gieryn, 2002 and Müller and Reichmann, 2015 for a wider STS approach). These studies analyse the relationship between architecture and society to show how architecture as intentional material artefact helps shape or replace human action, mould decisions, change perceptions and mediate human relations to the extent of prescribing morals and ethics. The focus in such studies is on the networks of human and non-human actants that together form assemblages and define architectural spaces, how they come to be and how they evolve over time. While certainly a step towards a distributional understanding of agency, critics of this approach highlight the lack of emphasis on the actual *doings* of the users of these spaces (Shove et al., 2012). Schatzki (2002) argues that in trying to establish a symmetrical view of human and non-human capacities in social life, ANT goes a step too far by ascribing intentional agency to (a wider variety of) non-human entities. On the contrary, he suggests that the understanding of human and non-human relations in the making of social order can be better understood through the language of 'doing' (2002, p. 200) in an analysis of practices.

Recently, the significance of architecture as materiality within practices that shape and define social order has gained momentum among some proponents of practice theory (e.g. Guy and Shove, 2000; Hand et al., 2007; Rinkinen et al., 2015; Rinkinen and Jalas, 2017; Kuijer and Watson, 2017). However, among practice theorists, while the relationship between building energy consumption and household practices has been well established, the role of house design in prefiguring household practices and consequent energy demands remains underdeveloped. In addition, most practice-based research remains focused on practices of homeowners (see e.g. Hand et al., 2005; Ropke et al., 2007; Gram-Hanssen, 2008, 2011; Halkier and Jensen, 2011; Maller et al., 2012; Foulds et al., 2013; Higginson et al., 2014 among others) and not of the professionals who design these domestic spaces. Such a one-sided approach creates gaps in the understanding of domestic energy demand and misses the critical links between housing and household practices for sustainability interventions. This requires a broader understanding of sustainable housing as an intervention in a whole system of practice that involve interrelations of many different stake holders, including those of housing professionals, policy-makers, designers and builders as well as daily routines and household practices of homeowners (Macrorie et al., 2015). Buildings as shared objects play a central role in connecting

professional and household practices (Jensen et al., 2014), and thus can be analysed as a bridge between household and housing practices.

Whilst the importance of architecture as materiality in a practice-theoretical framework has recently been examined by some social theorists (as mentioned above), the application of practice theory within the disciplinary boundaries of Architecture has been limited. Of the few examples is Behar's (2016) PhD dissertation on domestic ventilation practices from a socio-technical perspective. The author uses SPT to gain insight into how homeowner's ventilation practices are constrained and enabled by the physical arrangement of ventilation systems in their homes and how well they are aligned with the designer's intentions. It also reveals that interactions between residents and the professionals involved in designing, constructing and managing their homes can sometimes result in enhanced knowledge and improved engagements, leading to less energy-intensive practices. Similarly, Topouzi's (2015) PhD research on occupants' interaction with low-carbon heating and ventilation retrofits in social housing combines several theories, such as 'user-centred' theory with elements of SPT, in an inter-disciplinary approach. The thesis demonstrates that complex system of practices of various agents, interactions and individual users combine to determine a building's overall energy performance. Based on this, different combinations of measures and design solutions are required for specific housing typologies, locations and household types. While these studies pave the way for much needed research on the interconnections between the house architecture and social practices, the focus remains only on single practices (ventilation and/or heating practices) within households, without considering how these practices interconnect with other household practices as well as the wider practices of housing professionals. In addition, focus remains on the architecture and materiality of the house itself, without placing it in context of the wider urban fabric that forms the built environment.

2.4. Practice as a unit of analysis

Drawing on Schatzki's (2011) concept of prefiguration and role of artefacts in shaping practices, Kuijer (2014) presents a framework for using practice theory as a unit of analysis and design, based on extensive empirical research. The empirical research carried out in Part II of this dissertation is loosely based on the framework proposed by Kuijer (2014) for taking practice as a unit of analysis. A brief outline of the steps involved in the practice-analysis model is presented below. These include;

1. Quantifying consumption indicators.
2. Tracing historic career.
3. Exploring similar practices.
4. Mapping the target practice.

Before undertaking the framework, Kuijer (2014) suggests that the first stage in the analysis requires framing the practice in the sample setting and defining its boundaries. Once the practice has been defined, Step 1 requires an overview of the levels of resource consumption taking place in the target practice. These can be quantified based on energy consumed per unit of time per household. According to the framework, this step also involves determining contemporary and historic trends and varieties for target level determination. The quantification of electricity consumption in contemporary middle-class houses in Lahore was undertaken by the author during the MSc dissertation, collected through a questionnaire survey of 200 middle-class houses in Lahore and so, did not form part of this PhD research. Step 2 involves tracing the historic career of the target practice. This step formed the basis of Chapter 4 that presents an analysis of the coevolution of house spatial layouts and household practices. Step 3 involves studying varieties of the target practice in other settings and cultures. This step is particularly relevant in finding opportunities of intervention and was undertaken in Chapter 5 that focuses on a cross-cultural comparative study of household practices and their subsequent temporal and material arrangements in middle-class houses in Pakistan and Denmark. The final step requires mapping of the target practice, which was carried out in Chapter 3, using the conceptual framework provided by Shove and Pantzar (2005) to determine the socio-material characteristics of electricity-consuming household practices in middle-class houses in Lahore, Pakistan.

2.5. Practice as a unit of intervention

Recent work in practice theories has focused on using practices in moving beyond analysis of emergence and stability of the social to gaining insight into how practices change over time and across different economic, social and cultural contexts. According to a practice-based perspective, change takes place in the construction and transformation of collective convention (Shove, 2003) in social practices that 'constitute a site of resistance and challenge' (Halkier et al., 2011a, p. 9). According to Shove et al. (2012), the emergence and demise of practices are dependent on the forging or failing links between the components of practice, and how the elements fit together. Shove and Pantzar (2005) claim that consumers are 'active and creative practitioners' (p.45) and that new practices emerge from and as the consequence of specific consumer–producer interaction. The novel integration of the elements of a practice form new links and challenge old ones;

> '…innovations in practice depend upon the active integration of elements, some new, some already well established, that together constitute what we might think of as innovations-in-waiting or proto-practices.' (Shove and Pantzar, 2005, p. 48)

This integration of unfamiliar elements (or links) for change in practices are phrased by Schatzki as ‘contingent events’ (2001, p. 61); Reckwitz has called this phenomenon ‘crises of routine’ (2002a, p. 255), while Shove et al. cite them as ‘disruptive moments’ (2007, p. 31).

In framing an approach to societal transition, Schatzki posits that practice-arrangement bundles dissolve when over-whelming, frequent, or large-scale changes occur to them such as interruptions in material flows or through changed interwoven timespaces and practice organisations. Unlike the multi-level perspective of STS (e.g. Geels, 2002) or the structure/agency divide common in most social investigations, Schatzki (e.g. 2011, 2015) conceptualises social phenomenon as transpiring on a flat ontology, arguing that all social phenomena have the same basic composition. He opposes a top-down or bottom-up approach for intervention, rather presenting significance of scale, as practices link together into constituent bundles and constellations that together form a plenum, in asserting lesser or greater spatial-temporal spread.

Contrary to this, Watson (2012) combines theories of practice with socio-technical approaches like the multi-level perspective (MLP) to explain socio-technical transitions through the concept of ‘systems of practice’. Watson argues that multi-level systems and processes that result in transition inherently persist and transform through the flow of practices. These performances of practices reproduce the institutions and relations comprising the system at different levels, including those of public authorities, corporations, policymakers, marketing agents, maintenance and service sectors, etc. Using this systems of practice approach to analyse governance of housing policy and practice, Macrorie et al. (2015) posit that householders are just one set of carriers among many in a wider system of practice that includes working practices of housing professionals, designers and builders, etc., all of which are important stakeholders and provide relevant targets for intervention.

Taking practice as the fundamental unit to bring about change towards sustainability, Spurling et al. (2013) devised three key ways for interventions in practice, which are used for framing practice-based interventions in house design and use in Part III of this dissertation: These include:

1. Recrafting practices
2. Substituting practices
3. Changing how practices interlock

Recrafting practices means changing parts of the practice to make it less energy intensive. For example, improved appliance efficiency, skills training and information campaigns, etc. The key is to introduce or remove elements that will enable more sustainable forms of performance. This is considered a minor form of intervention, as it targets only elements within practices, while practices themselves remain intact. Substituting practices involves replacing unsustainable practice entities with more sustainable alternatives. This can be done by providing spaces and places that allow the more sustainable of two competing practices to be undertaken, for example cycle-racks instead of

car-porches, to enable cycling and inhibit driving. Alternatively, more sustainable versions of existing practices might be encouraged, for instance providing dedicated space for air-drying laundry, and none for tumble dryers. Finally, practices are generally interlocked in complex networks and wider systems of practices such that change in one can have ripple effects throughout the system. An approach to changing how practices interlock entails designing infrastructures and institutions that advocate spatiotemporal patterning of more sustainable practices, for example shift in social organisation of working practices that result in eliminating long journeys by virtual communication.

2.6. Summary

This research seeks to address the gap in energy use studies in developing countries in the Global South from a socio-technical perspective. It applies SPT to the study of energy consumption in middle-class houses in Lahore, Pakistan. Using Shove and Pantzar's (2005) practice element framework, it explores the relations between e electricity-consuming practices and the socio-cultural and material context of houses in Chapter 3 (research questions 1 and 2). Based on the empirical evidence and using Bourdieu's (1984, 1986) notions of class and capital, the research explores how practice theories can be adapted to energy use research in non-Western contexts in countries like Pakistan from the Global South.

The research addresses the evidence gap in practices theories in examining the role of house design in prefiguring household practices and consequent energy demands, exploring the links between household practices and spatial arrangements in Chapter 4 (research question 3). Drawing on Schatzki's (2010a, 2011) concepts of social order as a nexus of practice-arrangement bundles, it analyses the coevolution of household practices and house spatial layouts in Lahore to understand rising electricity demands in contemporary middle-class houses. The research further combines practice theories with the STS approach of architecture as mediator (e.g. Gieryn, 2002; Latour and Yaneva, 2008; Yaneva, 2009) to investigate the interconnections of materiality, in the form of architecture, in practices at different scales in Chapter 6 (research questions 5 and 6).

The thesis further develops understanding of the relation between practices and temporalities of energy use. This theoretical contribution is interwoven throughout the empirical work in this dissertation. This link is first explored in Chapter 3, when zooming in to the everyday routines of contemporary middle-class homeowners to understand the socio-material constructs of their electricity-use practices. Zooming out to develop a century-long socio-spatial trajectory of houses and household practices, a longitudinal frame of practice-arrangement temporalities is formed in Chapter 4. Finally, in comparing similar household practices in different socio-material contexts, the temporalities of practices bring forth the time-shifting capacities inherent in different energy systems in Chapter 5. Further, the conceptualisations of practice temporalities (e.g. Southerton, 2003; Southerton et al., 2012; Walker, 2014; Spurling, 2018) and their impact on demand management are

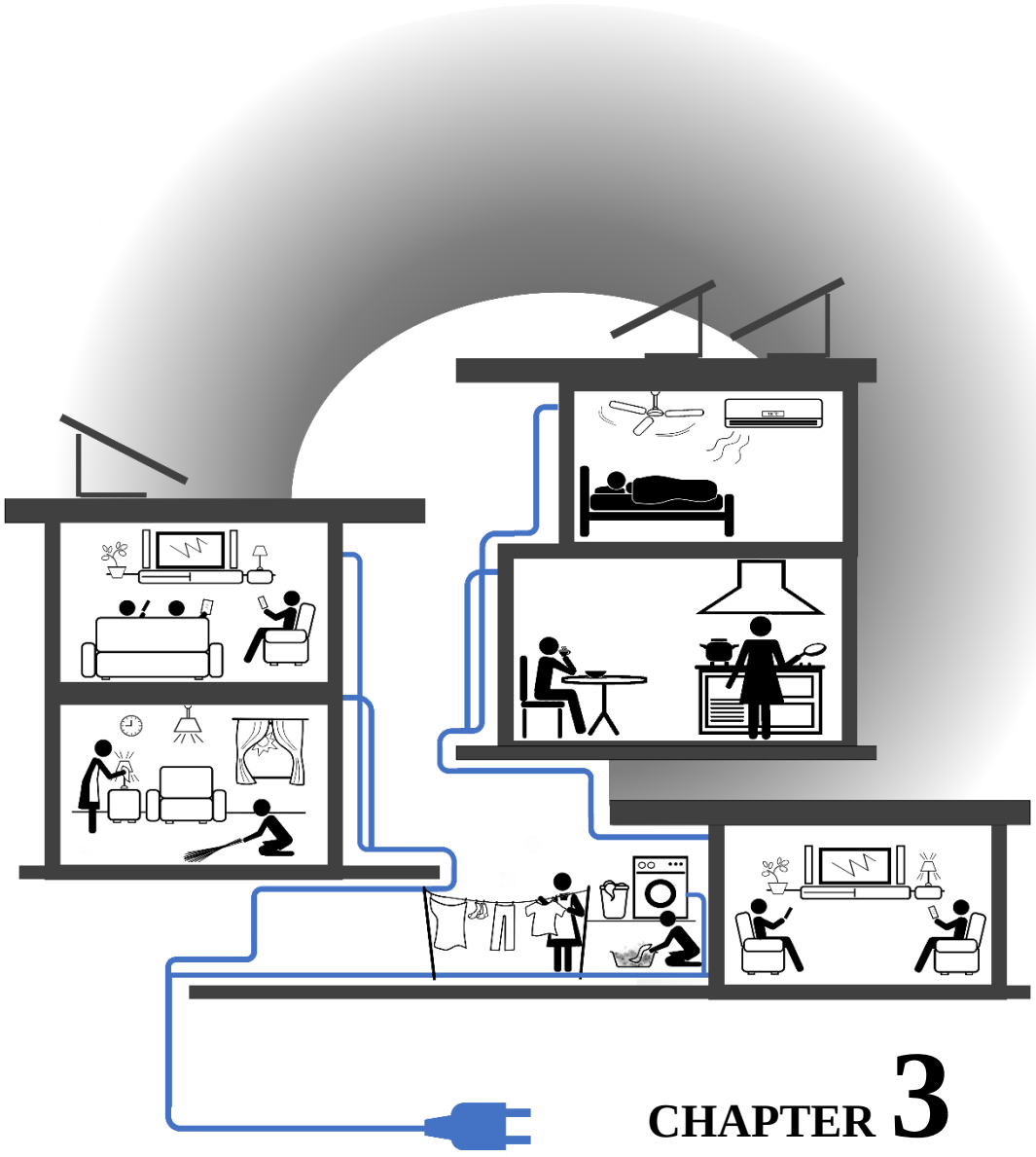
studied in depth in Chapter 5 to answer research question 4. The comparative analysis further adds to the limited studies that explore practice temporalities and materiality in different cultural contexts and their implications for demand management and response strategies.

The application of practice as a unit of analysis is further developed by the dissertation in Chapter 3, 4 and 5, the selection and progression of which is loosely based on Kuijer's (2014) framework of practice as a unit of analysis. Chapter 6 adds to the underexamined area of research on conceptualising practice as a unit of intervention in house design and use, drawing on Watson's (2012) system of practice approach and Spurling et al.'s (2013) practice-oriented intervention framework (research questions 5 and 6).

PART II

PRACTICE AS UNIT OF ANALYSIS

Part II presents the first empirical section of the study, taking practice as a unit analyses of domestic energy demand in three chapters. Chapter 3 identifies the various socio-cultural dynamics and material arrangements that shape and, in turn, are shaped by household electricity consumption in contemporary middle-class houses in Lahore. Chapter 4 presents a longitudinal historical trajectory, outlining the coevolution of household practices and house spatial layouts in Lahore over the last century and how these household practice-arrangements have become more energy-intensive over time. Chapter 5 focuses on a cross-cultural comparative analysis of household practices and electricity demand in middle-class houses in two countries, Pakistan and Denmark. It explores the interlinks between practice temporalities, materiality and socio-cultural contexts. Chapter 5 is based on a joint research paper with researchers from the Danish Building Research Institute at Alborg University, Copenhagen. This research is the result of a collaborative research project titled UserTEC, funded by Innovation Funds Denmark.



CHAPTER 3

3. Household practices and electricity demand

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Abstract

This research seeks to address the gap in studies of energy consumption in developing countries from a social science perspective. The research uses Social Practice Theory (SPT) to gain better understanding of homeowners' practices and resulting electricity demand in middle-class households in Pakistan, with broader implications for other developing countries with similar climatic and socio-material contexts. Drawing on the works of Bourdieu (1984, 1977), Schatzki (2011) and Shove and Pantzar (2005), the study aims to unravel the connection between familiar domestic practices and the 'uncanny' electricity demand. Material and social constructs of 'homely' household practices related to comfort, lighting, cleanliness, cooking and ICT were studied in ten middle-class households in Lahore, Pakistan. The material arrays of the intermittent electricity provision system, modernistic prefigurations of spaces preferred by the middle-class and electrical appliances play an intrinsic role in shaping, and in turn being shaped by, everyday practices. Practices are shaped by specific socio-cultural dimensions, such as social acceptance within the neighbourhood community, religious meanings, joint family structures, age disparities and gender segregation. The empirical study aims

to further the conceptualisation of socially differentiated practices in domestic socio-material and cultural context of developing countries.

Key words: Social practice theory; developing countries; household practices; electricity demand

3.1. Introduction

Rapid urbanisation and economic growth of the emerging middle-class in the developing world has resulted in their energy consumption overtaking that of the developed world, while their energy-use is expected to increase (Karakosta and Askounis, 2010; Wolfram et al., 2012). Yet policies tend to focus on energy generation (Alahdad, 2012), negating demand reduction. Taking energy demand as a for-granted need, as input for a pre-defined output (EIA, 2016), limits understanding of how and why this demand arises and evolves. This results in perception of energy as an abstract entity where the demand is seen as unpredictable and intangible, as in Freud's (1919) conception of the 'uncanny'[4]. Energy is an intrinsic part of the daily, familiar routines, but remains 'visibly invisible' and the demand uncertain, unfamiliar.

An argument has been made for a paradigm shift to look at energy practices as social construct rather than (rational) behaviour as in previously dominating theories building on economics and psychology, based on the attitude, behaviour and choice (ABC) model (Shove, 2010). Research on everyday routines and practices in shaping household energy demand is well established in Western energy studies (see e.g. Røpke et al., 2008; Shove, 2010; Halkier et al., 2011; Warde and Southerton, 2012; Shove and Walker, 2014; Schmidt and Weigt, 2015). In addition to its well-known applications in domestic energy use (e.g. Shove, 2010; Gram-Hanssen, 2010, 2014), theories of practice have been used to examine domestic DIY activities (e.g. Maller et al., 2012; Hand et al., 2005; Watson and Shove, 2005; Karvonen, 2013) and professional retrofit practices (e.g. Palm and Reindl, 2016), in Western countries. The significance of materiality in the emergence, persistence and reproduction of everyday household practices has been empirically researched in consumption studies (e.g. (Kuijer et al., 2013; Strengers, 2013; Powells et al., 2014; Rinkinen et al., 2015; Foulds et al., 2017). Further, Shove (2014) argues that a better understanding of energy use as a social construct could lead to more effective and legitimate policy-making.

However, most empirical work that makes use of theories of practice is limited to Western case studies, with a limited number of exceptions that are explored in the following section (e.g. (Wilhite, 2008b; Sahakian, 2014; Smits and Rinkinen, 2016; Smits, 2015; Browne, 2016). This has led to two

[4] The term uncanny, with its varying nuances, has been linked with domestic spatiality and architecture in the works of Freud (1919) and Vidler (1992) respectively, depicting the transformation of something as homely and familiar as domestic architecture into something defamiliarised and strange by the spatial incursions of modernity. Although used for architecture, the essential but ever-changing, visibly invisible nature of energy probed us to link it to the energy discourse.

limitations; firstly, the pool of shared practices that the above-mentioned studies draw upon for their conceptualisation and understanding of practices are predominantly confined to Western countries. Secondly, the applicability of findings from this body of work in the context of developing world is limited by the fact that each developing country has its own unique, socially and materially structured set of inter-linking ideologies, cultural norms and pace of progress that shape the continuity and change of practices within the society (Qadeer, 2006). There is limited understanding of the materiality of the housing stock in developing countries, which for example for the middle-class households is increasingly inspired by Western lifestyles - and how that materiality responds to local climate and culture.

This paper aims to expand the understanding of how practice theories can conceptualise electricity demand and household practices in the socio-material context of developing countries, taking middle-class households in Lahore, Pakistan, as case-study. Based on semi-structured, in-depth interviews and observations in the households, the research aims to answer the following questions in the case study context: How do the material arrangements adapt to and shape everyday household practices and the resulting electricity consumption? What role do the socio-cultural dynamics play in structuring homeowners' daily practices and the resulting electricity consumption?

Literature review is presented in section 3.2 and the empirical study is described in section 3.3. Section 3.4 describes the findings and conclusions are drawn in section 3.5.

3.2. Theories of practice and energy use

Practice theories provide an integrated framework to conceptualise a duality of social structuring: structures condition human activity, which through their recursive reproduction through practices, reconstitute these very structures (Giddens, 1984b). According to Giddens (1984), practices are based on people's shared understandings (authoritative or allocative 'rules') of the world. The 'practice turn' in social theory led to conceptualisation of social practices as the central unit of analysis, taking practices as the site where 'understanding is structured and intelligibility articulated' (Schatzki, 1996, p. 12). Compared to ideas dominating in disciplines like psychology or economics, practice theories divert attention away from individuals' (rational) decision-making towards wider societal structures. Practice theories suggest that our common practices are not shaped by a large number of individuals acting independently but are dictated by interconnected sets of social norms, infrastructure, embodied habits and understandings. The notions of 'practice theory' and 'practices' have several different meanings in social science but their use in energy research has been based on Schatzki (1996, 2001) and Reckwitz (2002a) whose work has been introduced to energy studies by Warde (2005) and Shove and company (2012) and applied and elaborated on by researchers like Gram-Hanssen (2010, 2014a). While practice theories are applied to empirical studies, it should be noted that they have been primarily interested in the mechanisms of how a society works and not developed as a convenient

framework for empirical studies in energy demand reduction. They can, therefore, be more useful as a heuristic rather than representational model (Galvin and Sunikka-Blank, 2016).

To date, theories of practice consist of varied concepts and frameworks defined by authors of diverse disciplines (see e.g. Gram-Hanssen (2011) and Shove and Walker (2014) for summary of these definitions) but the models of Shove and Pantzar (2005) and Gram-Hanssen (2011) are most commonly used in energy studies. Material dimension associated with practices takes a central place in all energy consumption studies. Gram-Hanssen (2011) focuses on technology as the material constituent of practices in societal transitions. Shove and others (2005, 2012) adopt a wider definition and consider materiality as an all-encompassing whole and for this reason, the framework by Shove and Pantzar (2005) was adopted in this research. Their conceptualisation presents practices as the interconnected relations between three elements: materials (including objects, infrastructures, built environments, tools, hardware and the body itself), meanings (representing the ethos, norms, aspirations, ideologies, symbolic significance, perceptions and the reasoning in carrying out practices) and competences (understanding, know-how, the learnt bodily and mental routines) (Shove et al., 2012, p. 25).

Contrary to Giddens, Schatzki (1990, 1997, 2002) whose approach Shove's model (Shove and Pantzar, 2005) is based on, sees habituated skills, practices, instead of 'rule'-following, as an explanation of human actions. For Schatzki, practices are organised through three dimensions: practical understanding, explicit rules and teleoaffectivity while socio-economic aspects receive less attention, as also in the work of Reckwitz (2002a, 2012). Consequently, cultural capital and socioeconomic factors, and how these influence the formation of practical consciousness, have not been at the core of practice theory studies in energy research. In order to include socio-economic aspects and their relation to practices (and compare rich and poor countries), this study also draws from the work of Bourdieu (1977, 1984). As one pioneer of practice theories, Bourdieu provided an understanding of practices within the context of the individuals' inherent disposition, 'habitus', available means or resources, 'capital' and the social arena, 'field'. For Bourdieu, social differentiation of practices is a key theme. In addition to dispositions formed by past experiences, individuals draw upon socio-economic and cultural resources, demarcated as 'capital'. The various forms of capital are both embodied and objectified in individuals' pursuit of class distinction and desirable social standing and together, these play a central role in defining their positioning and performance of practices in the social world. Bourdieu (1984, p. 101) defined practice as:

$$[(\text{habitus})\ (\text{capital})] + \text{field} = \text{practice}$$

Using Bourdieu's conceptualisation helps to understand class as not just formed of economic capital, but also of cultural and social capacities. Bourdieu distinguishes between three forms of cultural capital: institutionalised, embodied and objectified (Bourdieu, 1986). The concept of how class

registers cultural divisions continues to be applied in socio-cultural studies (see e.g. (Bennett et al., 2009; Savage et al., 2013; Purhonen et al., 2014; Darmon and Warde, 2016). However, Bennett et al.'s (2009) extensive work on cultural and class distinction in Britain warrants additional forms of capital to supplement these somewhat restrictive categories. Class and taste have been little studied in the context of developing countries and in this study, efforts were made to understand middle-class household preferences and aspirations in the interviews.

Social and cultural paradigms within which practices are undertaken 'constitute a site of resistance and challenge' (Halkier et al., 2011b, p. 9) involving adjustment, interpretation and alteration - a concept that demands particular attention in studies of consumption in different contexts. Warde (2005) contends that practices are internally differentiated as the practitioners in different situations carry out the same practice differently. Such differentiations are further compounded by the social differentiation of the same practices in different ethnic groups (Halkier and Jensen, 2011b; Maller, 2011) and between different cultural dispositions (Wilhite et al., 1996; Matsuhashi et al., 2009; Rinkinen and Smits, 2016) or even between cross-national contexts (Darmond and Warde, 2016).

In addition, the individual acts as the 'intersection point' (Warde, 2005, p. 144) of many different practices. The study of single practices negates the significance of the connections, conjunctions, alliances and conflicts that exist between simultaneously occurring or existing practices (Hargreaves, 2011; Rinkinen and Smits, 2016). Study of such bundles of loosely knit or complexes of more tightly knit practices (Shove et al., 2012) or plenum (Schatzki, 2011) highlight the interlinking nature of everyday practices. According to Schatzki (2011), social phenomena are slices of a plenum of linked arrangements and practices through five types of relations: causality, prefiguration, constitution, intentionality and intelligibility. The notion of prefiguration becomes particularly important in a unique socio-cultural and geographical context as it describes the role of the present (plenum of linked practices and arrangements) to changes in the future. Most studies of practices focus only on a single practice such as cooking (e.g. Halkier and Jensen, 2011) or laundering (e.g. Higginson et al., 2015). However, to get a comprehensive understanding of overall energy demand, a deeper understanding of interlinking compound practices is required, with an acknowledgement that practices are taking place within a socio-spatial context, such as a household or work place. This study aims to understand the total electricity consumption within a household and therefore interlinking household practices (comfort, lighting, cooking, cleaning and ICT) are studied.

Socio-technical studies of electricity consumption, in particular from a practice-based perspective, in developing countries have been limited. Exceptions include Wilhite's (2008) work on consumption and societal transformation in Southern India, and Sahakian's (2014) research on increasing practices of urban air-conditioning in four mega-cities in Southeast Asia, due to globalisation. This has been corroborated by Smits' (2015) take on the conflicts between modernity and sustainability in Southeast

Asian energy transitions. Browne's (2016) review of the history and patterns of water consuming practices in China calls for an extension of research work in the Global South, to form an enriched understanding of consumption from the socially differentiated practices that are bound by their context-dependent cultural, material, social and political realities. Since most contemporary empirical studies of practice are located within the socio-cultural context of Western countries (see section 1), the relation between social practices, class and culture in studies of consumption in developing countries has not been much explored.

This study seeks to fill this knowledge gap by taking a practice-based approach to demystifying the 'uncanny' electricity demand of middle-class households in developing countries, focusing on Pakistan. It identifies the material and social structures that shape everyday 'homely' household practices. This research sets its theoretical foundations in the work of Shove and Pantzar (2005), drawing from Bourdieu (1977, 1984, 1986) and Schatzki (2011). By taking a combined account of overall electricity consumption through various interlinked household practices, the study seeks to overcome the limitation of studying practices in isolation.

3.3. Methodology

The investigation of daily household practices was conducted in a case-study of ten middle-income households in Lahore, Pakistan. Pakistan is an interesting case-study as it has been identified among top ten countries most vulnerable to climate change (Kreft et al., 2015); it faces escalating trends in urbanisation and ever-increasing gaps between energy demand and supply (HDIP, 2015). In Pakistan, as in many developing countries with similar socio-economic and climatic constraints, the common response to demand management is electricity load-shedding, where power is shut down intermittently for 6-8 hours in urban centers as a last resort to overcome the energy gaps.

The sample group represents the middle- to upper-middle-income households in Lahore, Pakistan. Ownership of urban housing stock in Pakistan is concentrated in the middle and upper-income bracket and constitutes the bulk of the domestic energy demand (Shaikh, 2016). Lahore is the second largest city of Pakistan, with an estimated population in excess of 10 million. Lahore was selected as a case-study due to a representative group of middle-class households and its' on-going expansion with development of several new housing schemes that cater to middle and upper-income groups. The dominating housing typology, usually located on a plot size of 420m^2 (locally known as "1 kanal") was chosen as it represents the most common plot-size within Lahore Metropolitan Area and caters to the selected income group (HIES, 2015). Homes built on these plots are usually two-storey detached masonry houses, with four to five bedrooms along with one or two rooms for in-house staff. Most households have joint or single-family structures usually accommodating five to ten occupants. Efforts were made to ensure that the case-study sample would be a good representative of varying

socio-demographic characteristics embodied within the specified income group, representing a range of family structures, number of occupants, education level and age.

In-depth semi-structured interviews were conducted in ten case-study households. Semi-structured interviews provided an opportunity of heterogeneity in conversation, much more nuancedly enriched than the forced homogeneity of quantitative surveys. A full list of the interviews, with pseudo names for participants and household demographics are given in Table 5. A total of 21 persons were interviewed, a maximum of three from a single household. All interviews were conducted within the houses of the occupants in July and August 2016 and lasted from 60-100 minutes. The interviews were followed by a guided tour of the house, accompanied by photography, general observations and informal conversations. Home tours as a method for researching practices is now recognised as a valuable means of participant engagement with spatio-material aspects of their practices ((Powells et al., 2014). In the present research, the walk-through tours helped substantiate the interview findings, make links between spatial arrangements of practices and in certain cases brought to light elements of the homeowners' practices that had not been brought forth during the interviews.

To get a comprehensive understanding of overall electricity demand in households, practices related to the following areas that define households' electricity consumption were analysed; comfort (including space cooling/heating and ventilation), lighting, cleanliness (including house cleaning and laundering), cooking (including food preparation, food storage and dining), and ICT/digital entertainment. Bathing practices were not included in the study, as it does not directly result in electricity consumption in the present case. The selection of practices related to these areas was guided by the work of Gram-Hanssen (2008) with the aim of acquiring a holistic understanding of the household daily routines and practices that result in overall electricity consumption in households, hence negating the shortcomings of investigating practices in isolation.

All interviews were recorded, translated from Urdu to English, and transcribed. The interview findings were coded and analysed using NVivo 11 (a type of CAQDAS- Computer Aided Qualitative Data Analysis Software), which facilitated the coding process by providing structure and organisation to the analysis work. In the first instance, provisional codes were used to collect data for each practice. Once the interviews were transcribed and deductively coded, first cycle coding was done. Eclectic coding was used for second cycle coding, which were then peer-reviewed for elimination of researcher bias and validation. Finally, major themes were identified within the context of practice theories.

Table 5: Household and Interview participant demographics

Interview label	No. of occupants	Family structure	House construction type	Years in house	Interview participants (pseudo names)	Age	Gender	Occupation	Education level
				11	Mr. Asim	60+	Male	Self-employed	BA/BSc
A	7	Joint Family*	Self-built	11	Mrs. Asim	51-60	Female	Housewife	BA/BSc
				11	Mr. Arif	20-30	Male	Self-employed	BA/BSc
B	4	Single Family	Self-built	19	Mrs. Bashir	41-50	Female	Housewife	BA/BSc
				19	Ms. Bisma	20-30	Female	Student	MBBS
				20	Mr. Cyrus	31-40	Male	Unemployed	MA/MSc
C	5	Single Family	Bought as built	20	Mrs. Chishti	51-60	Female	Housewife	BA/BSc
				20	Ms. Cemaal	20-30	Female	Student	MPhil
				15	Mrs. Dawood	51-60	Female	Housewife	MA/MSc
D	9	Joint Family	Self-built	15	Ms. Duriya	51-60	Female	Housewife	BA/BSc
				8	Ms. Dua	31-40	Female	Housewife	MA/MSc
E	11	Joint Family	Self-built	24	Mrs. Ejaz	51-60	Female	Housewife	FA/FSc †
F	7	Joint Family	Self-built	18	Mrs. Furqan	51-60	Female	Housewife/ Charity worker	MA/MSc
				18	Mr. Fareed	31-40	Male	Full-time Employed	MA/MSc
G	5	Single Family	Bought as built	8	Mrs. Gulzar	31-40	Female	Housewife	BA/BSc
H	6	Single Family	Self-built	22	Mr. Harris	51-60	Male	Self-employed	BA/BSc
				22	Mrs. Harris	51-60	Female	Housewife/ self-employed	BA/BSc
I	8	Joint Family	Bought as built	2	Mrs. Imran	51-60	Female	Housewife	MA/MSc
				1	Ms. Izza	20-30	Female	Housewife	MA/MSc
J	11	Joint Family	Self-built	19	Mrs. Jamal	51-60	Female	Housewife	FA/FSc
				19	Ms. Jamila	20-30	Female	Student	MA/MSc

* Indicating more than one nuclear family living within the same house, e.g. main couple's family living together with the married son, his wife and children.

† Pakistan's academic degree for Higher Secondary Certificate equivalent to GCE A-Levels in UK.

This study is based on a case-study approach (Yin, 2014) and due to the limited sample sizes the paper does not aim to statistically generalise its' findings, but focusses on interviewee narratives and understanding the characteristics of daily practices, how they relate to materiality and could be harnessed in policies, drawing from the work of Shove and Pantzar (2005) and Bourdieu (1977, 1984) in relation to practice theory as discussed in the previous section. Focusing on ten households helped to ensure that detailed examination would be possible through in-depth interviews and observation. Strauss and Corbin (1998) contend that although data saturation is probably never achieved, detailed coding and inspection of at least ten interviews or observations are required for theory structuration – this is also a convention in the field of qualitative energy studies (see e.g. (Galvin, 2015). For the

present study, it is argued that the sample of ten was found to be sufficient as, although no claims of statistical generalisations are made, the case suffices to identify key characteristics of household practices that differ from those in Western households and start a conversation of how they could potentially be addressed in policies. In the last few interviews less new themes emerged and the narratives corroborated the previous findings suggesting a level of practical saturation. Further, since the aim of the study was to expand on the concept of social differentiation of practices, even single examples that refute the idea of a homogenised practice perspective would serve as evidence of falsification, as argued by Flyvbjerg (2006) who negates the requirement of large random sample where one critical case is sufficient to prove or disprove a particular hypothesis. As an example, in the present study, if an element of practice was recorded in an interview (i.e. religion or gender in shaping temporal or spatial practices), it exists and any blanket statements that overlook it, are negated.

Gram-Hanssen (2014) argues that within energy consumption studies, it is often preferable to combine a qualitative interview approach with actual measurements, not to validate what the interviewees say but to understand how the objective measurements relate to the subjective understanding of perceived indoor conditions and how measurements relate to the expressions of indoor-climate practices. Electricity use data of the interviewed households was collected from their electricity bills but comparison at this stage of the research was not possible due to inconsistency of the data[5]. Detailed quantitative measurements will be conducted in the next stage of the research.

3.4. Findings

Household practices were analysed using the conceptual framework of Shove and Pantzar (2005). The findings are presented here in relation to the material arrangements and socio-cultural dynamics of practices, especially in comparison to Western countries.

3.4.1. Practices and material arrangements

One key aspect that shapes homeowners' daily routines in Pakistan is the intermittent electricity supply system. Scheduled power outages for 6-10 hours during the daily 24-hour time-period mean that the Pakistani homeowners consistently rearrange their energy-use practices to accommodate the shifting magnitude and frequency of load-shedding schedules:

[5] With the same house size and metering system, the electricity consumption data varied considerably, in some cases up to 5.6 times. Where this can be attributed to disparities in occupants' energy-use, however the irregular meter readings, adjustments made to billing to account for line losses and other faults as accounted by the homeowners and evidenced in the bills made simple quantification through electricity bills inaccurate and unreliable.

> "We had to make changes and adjustments because of it (load-shedding) obviously. We had to schedule when to do the laundry according to power outage times. We think about every part of our routine based on when the light will be out and when it will come back. We have had to manage and set our entire day according to it. Everyone has done that. This is an issue which we have been facing for many years now, so we have had no choice but to do this. Now we have all become very much used to it." (Interview A)

> "We have to plan- when we have electricity, we think okay, I need to do this, and this and that before the electricity goes out. Most often, it's the ironing I have to worry about. The maid also has to consider the electricity hours." (Interview J)

Shortages in electricity and load-shedding schedules mean that homeowners are acutely aware of the presence (or absence) of electricity. The continuous availability of electricity in the developed world can result in disengagement with energy (Pierce and Paulos, 2010) due to its 'invisible, unremarkable and unrecorded' ((Warde and Southerton, 2012, p. 6) nature. Contrary to this, Pakistani homeowners' engagement with electricity was much more meaningful and grounded in material reality (through the various systems of electricity provision described below):

> "The first thing I do after I get up is to switch off all the lights that were on during the night… I don't think we are careless users. All of us take care that if a light isn't being used, we do switch it off." (Interview B)

Switching off lights for saving electricity was common among most of the homeowners. Tangibility of electricity in this regard is high. This can be observed in Urdu conversation, where the term 'light' is used to interpret 'electricity', and electricity consumption is a common topic of discussion because of load-shedding;

> "Here, if you have to go visit someone, they will tell you their electricity schedules, so that you don't end up visiting them at a time when there isn't any electricity in the house. You must have come across such jokes as well that Pakistanis now talk in terms like, 'So is your's there?', 'Ours isn't there!'. We have become so used to this! We are going back in time, back to the stone age!" (Interview H)

The electricity bill is also a common topic for conversation, a recurring concern voiced by all Pakistani households. Awareness of the monthly billing is a matter of importance for everyone in a household:

> "We all look at it. The older son pays the bill. We all look at the amount, not in greater detail. Dua looks at it quite thoroughly. That's because there was a problem with it once. It came up to PKR 24,000. That was too much. No one among the neighbours had such a high amount." (Interview D)

Where dependency on an intermittent supply has made homeowners more flexible and resilient in managing their day to day practices; conversely, it has also led to the emergence of a new material culture in households to seek continuation and stability of practices. All households interviewed had mechanisms for localised electric power generation or storage for periods of load-shedding. These included UPS (Uninterrupted Power Supply) systems[6] (Figure 3), generators and more recently, Solar Photovoltaic (PV) systems (Figure 4).

Figure 3: UPS system (Interview A)

Figure 4: Solar PV system (Interview F)

In addition to back-up systems, the type of appliances and equipment selected and used is very much dependent on energy regime. This was evident in the use of energy efficient lighting such as LEDs (Light Emitting Diodes) and CFLs (Compact Fluorescent Lights), which are better compatible with load-shedding, as more lights can be switched on and for longer on micro-generation/battery power. Fluctuation in voltage also makes use of CFLs less suitable than LEDs and was cited by one homeowner as the reason behind its installation;

> "One thing is that they give much more light than the usual simple (conventional) bulbs, secondly, in Pakistan as u know there is load-shedding, so the simple bulbs don't have that long life, so one advantage that these bulbs have is that when there is sudden failure, the concentration of light is maintained. Also…if the voltage gets high suddenly, or drops, these bulbs fuse, you must know, they just blast. The others don't do this." (Interview A)

[6] An Uninterruptible Power Supply/Source (UPS) is an electrical battery storage system for emergency back-up power to a load when the input power source or mains power fails.

The interviews suggest that electricity, and more broadly energy, plays an intrinsic role in the decision-making of Pakistani households; from the myriad of material elements for electricity storage and generation that define what practices can be undertaken to the load-shedding schedules that determine when these practices can be performed. As such, electricity (and energy in general) becomes more a material component of everyday practices. A similar conceptualisation of energy has been put forth by Strengers (2012) who argues that integration of smart metering and demand management systems provide examples of the collapsing supply-demand divide in which 'electricity systems become an active element in the practices they enable' (p. 230). Where the present study serves as a case in point for this proposition, future systems will only serve to strengthen the conceptualisation of energy as a material element within everyday practices.

Apart from the electricity provision system and individual electric appliances, another material component that shapes everyday practices are physical spaces where these practices take place, the domestic architecture itself. During the interviews, a question surfaced on what kinds of practices does the physical structuring of contemporary design normalise or prefigure? Alternatively, how has current domestic architecture adapted to evolving practices?

The historic trajectory of house design in Lahore has evolved from a vernacular architecture with a traditional central courtyard design, based on sensibilities of simplicity, functionality, passive means of comfort and cultural norms to a compact, dense, deep-plan configuration of concrete, glass and brick masonry conforming to the modern movement (Mumtaz, 1985). Vernacular architecture was characterised by the use of passive techniques and indigenous materials such as thick brick masonry walls plastered with lime mortar, high ceilings and small windows near the ceilings that acted as ventilators and resulted in comfortable indoor temperatures and passive cooling of houses.

In the present case-study, evidence of the dichotomic interdependence between architectural spaces and household practices surfaced during conversation with the homeowners:

> "We wanted a spacious home, that is why we designed very wide, big windows, so that we get lots of daylight and fresh air, as air-conditioning wasn't very popular and conventionally used in those days. As time passed, and ACs were installed, we realised that the windows are very big, so we had to reduce the size of the windows of the entire house, both length wise and breadth wise" (Interview F).
>
> "Well, in the summers, we do have this problem, that the lounge is too big, and the stairs to the first floor open directly into it, so we cannot really cool this space. We do think about installing glass doors or a separation for the stairwell, so that we can make the lounge more comfortable, as that is the most used room in the house." (Interview C)

This results in conflicting requirements where openness competes with space cooling. Windows are often blocked externally with green cloth or bamboo blinds to prevent excessive heating in summers, as evidenced in the case studies:

> "The thing is, in my room I don't have any system for daylighting, because we have covered the windows with shades externally to stop heat and sunlight getting in. In the kitchen, when we have sufficient light, then we don't use artificial lights till that time, but then when the cooking needs to be done, then we have to use lights. We don't get a lot of daylight inside the rooms." (Interview G)

Six of the ten households interviewed could not use their open-plan living rooms in summer due to a lack of appropriate thermal control. This results in the master bedroom functioning as a multi-purpose space:

> "My bedroom, this is now our lounge, our living room, our bedroom, our dining room, we practically do everything here! Especially now in the summers, as the AC is on here, so everyone stays here. If we switch on the AC in the lounge, as its open from all sides, it takes so much time for it to become comfortable" (Interview E)

This is an example of how contemporary houses, preferred by middle class households in countries like Pakistan, can facilitate inefficient practices that lead to reliance on air-conditioning for thermal comfort. These findings echo those of Wilhite's (2008) and Sahakian's (2014) historic review of air-conditioning in southern India and Southeast Asia respectively, where natural cooling techniques and traditional house design were overthrown by the onset of modern 'Westernised' architectural practices. Alternatively, Nicol and Humphreys' (2002) study of comfort conditions in buildings in Pakistan shows how passively designed buildings not only reduce the electricity profiles, but also help to improve the 'adaptive opportunity' offered to occupants.

One adaptive measure most homeowners were found to take in the present study was the variance in space usage patterns in different seasons, particularly the use of the first floor was often put on hold in hot summer months because of very high indoor temperatures:

> "In winters, all the upstairs rooms are in use. But in summers, we try to use only one room. So, the other children sleep in my daughter's room downstairs, on mattresses on the floor, so that one AC is on… this is only to make sure that the electricity bill isn't too high." (Interview J)

Privacy is an important issue for most of these middle-class homeowners, particularly for the females, who are usually subject to religious and cultural norms of hijab[7] and require segregation of spaces or planning in a way that maintains privacy. In this regard, open-plan houses fashionable in contemporary Western architecture, and now gaining popularity in Pakistan (six out of ten case-study households), often prove incompatible with the identified cultural and moral sensibilities (Figure 5 and 6). Mrs. Furqan:

> "The TV lounge didn't have any partitions. This entire area used to be one big open space. The house was planned such that the kitchen and dining room both open into the lounge, they are linked through the lounge basically. This causes a problem for me. When we have guests over, and we are very social, the house staff has to cross the lounge to reach the dining area, which becomes uncomfortable for some guests." (Interview F)

Figure 5 and Figure 6 : Large open-plan living rooms (Left: Interview E; Right: Interview F)

Provision of a central courtyard has been a key aspect in vernacular Pakistani architecture, in keeping with traditional Islamic architecture. Such courtyards provided a private open space for homeowners, particularly women, to carry out numerous daily practices, not only ensuring privacy but also a connection to outdoors. The contemporary house design, as in the case studies, has all but severed the connection of the indoor with the outdoor space. Outdoor spaces are very limited and designed in a manner, which makes them unusable to most homeowners owing to cultural issues of privacy and impracticality. Low boundary walls and the absence of parapets on terraces are in contradiction with the need for privacy by most homeowners. Mrs. Asim:

> "For me, it's also for privacy! I like that the curtains remain drawn always!... We can go and sit outside, but there is no privacy. I am thinking of doing

[7] Covering of the head and modest loose clothing. In Pakistani culture, a *dobatta*- large piece of cloth to cover the head and torso- is traditionally worn by women in public.

> something on the terrace for that. If you sit in the garage, there is no privacy." (Interview A)

Browne (2016), in reviewing hygiene practices in China, explains how the transformation of the urban fabric led to an evolution of not just the materiality, but the sociality of the practices. With current connections between indoors and outdoors severed by modern house designs, many outdoor practices have become obsolete, as explained by Mrs. Harris:

> "Outdoor sitting practice was much more…to sit outside in the lawn. My father loved fruits, so instead of a lawn we had a fruit garden. My brother used to harvest honey bees as well. For studying, we would bring out small tables as well. We would switch on pedestal fans, even have tea outside. Now this practice has died away." (Interview H)

The provision of a second kitchen upstairs in joint family households provides another example of the disparity between the designed spaces and daily practices in Pakistani households (see section 4.2). These findings support Schatzki's (2011) views on practices and arrangements: prefigurations in material and social arrangements make 'some actions, inter alia, easier and harder or more direct or circuitous than others' (p. 10). Hence, prefiguration within spatial arrangements conditions and competes with the various images, skills and (other) materiality that define the performance and adaptability of current and future practices.

3.4.2. Socio-cultural dynamics in everyday practices

The interviewed homeowners often referred to their practices in relation to wider social and cultural contexts, such as expectations and acceptance of their practices within their neighbourhood. They mentioned how their practices typically echoed those of their neighbours and how certain actions, being common, then became justified in society. Mrs. Gulzar justified having an illegal gas regulator[8] installed in her house because her neighbours had done so as well:

> "There are nine regulators on their (referring to her neighbours) wall!... It's not legal, it's against the law. You see, they are in bed with the line-men. They give them money. Now, I have installed one as well and you know what, the Sui gas people said to me everyone on this street has one installed, you can install one too..." (Interview G)

[8] A gas regulator is a valve that responds to pressure changes and functions to regulate the flow of gas at the proper regulator gas pressure. In the present case, these valves are used to increase incoming levels of gas during shortages.

The interviews suggest that social image plays a significant role in household decision making in these middle-class households. For example, the exterior of the house in Pakistan can often provide judgements of economic, as well as social and cultural capital of homeowners; in the language of Bourdieu (1984): a visual display of the 'judgement of taste'. Those homeowners who were found to generally lay more emphasis on social perceptions (Interview A, G and I), had more elaborate and decorative house exteriors. Social image also plays a critical role in the interior. This is explicitly portrayed in the décor of the drawing room, a space designed for socialising, but also evident in other, more implicit means. Mrs. Asim presented a prime example of this when discussing her desire for buying a fourth refrigerator for the household:

> "You know what my son's major concern is regarding this. He says what will people say? That they are so wasteful? They have four fridges in their house?! From the beginning, he says what will people say? When my friends come over, what will they say, why we have three, four fridges in our kitchen? There shouldn't be more than one or two." (Interview A)

This concept has been highlighted by Wilhite and Lutzenhiser (1999, p. 281), who state that 'necessary' consumption often becomes a mark of social accomplishment and standing. A homeowner who had recently installed solar panels and replaced all lights with LEDs, still had four window air conditioners installed that are commonly known to be inefficient. Although no reason was provided by the homeowner for not up-grading the ACs, one possible answer could be the lack of 'conspicuousness' which, as has been highlighted by Wilhite and Lutzenhiser (1999), can play a significant role in energy retrofit decision-making.

One key finding unique was the emergence of religious factors in relation to daily routines and practices of middle-income Pakistani homeowners. Religion was brought up explicitly by eight of the ten homeowners as a constituent of their daily practices - reasoning for their doings and sayings. Moreover, its influence on temporal arrangement of practices within the households was evident. Mrs Asim had a completely different routine for Fridays than the rest of the week, because of the Friday congregational prayer:

> "I typically do the laundry daily, except for Fridays... On Fridays, I normally try not to use it…because of the water issue. Everyone has to use water in the washrooms, so I don't want there to be shortage. Also, all the attention is mostly concentrated on that (the Friday congregation). Even my cooking on Fridays starts after 3pm." (Interview A)

Sustainability has recently been linked to religious perceptions in Western literature (Palmer and Finlay, 2003; Berry, 2013, 2014 among others), although the concept is not new (White, 1967). In

the Global South, Wilhite (2008) reflects on the lack of conflicting political and religious ideologies in southern India, both of which seem to promote (or at least accept) increasing levels of consumption. In this case-study, however, religion, or at least the ideologies or rituals that it dictates, seems to be rooted within the frameworks of sustainability;

> "I do believe that we shoudn't wastewater. We do try to avoid wastage, in any form…The reason that motivates us isn't because of the environment, but I think more on religious basis…we know that we cannot be good human beings if we are wasting things...it's wrong, it's not the right thing to do…that's what our parents taught us." (Interview F)

> "I believe that nothing should be used more than is necessary, even if you have excess of anything. It's our religious obligation, you know." (Interview E)

Where social and cultural factors can be underpinned as 'capitals' in Bourdieu's framing of practices, in the context of this case study, religion can be seen as a form of cultural capital, since religion stands as an institution in its own right in Pakistan, and the acquisition of religious knowledge is deemed honourable and esteem-worthy. This offers potential for policy formation and marketing interventions or engaging religious groups as intermediates in policy implementation. One such example in Pakistan was seen in the public campaign for cleanliness in Islamabad. With slogans of a well-known Hadith[9], 'cleanliness is half of faith', the campaign aimed to reduce trashing and throwing garbage on the streets through religious motivation. Drawing on this perspective, it could be argued that if economic, or social and cultural capital drive consumption, exploring how acquisition of elevated 'religious capital' or, using a broader term, 'spiritual capital' might serve to regulate consumption in these middle-class households could prove to be beneficial.

Narrowing the perspective from the wider neighbourhood community to the internal workings of the household itself, it becomes evident that complex family dynamics play an important role in how daily practices and domestic routines unfold. In Pakistan, as in broader South Asia, family has fundamental social importance, as Wilhite (2008) posits in his study of southern India, 'consumption invokes family, and family networks are important to acquisition of goods' (p. 165). The modern-day urban society of Pakistan has evolved from intertwined ideologies of acceptable progression and valued stability. Qadeer (2006) articulates this unique socio-cultural transformation by positing that 'in the consumption and adoption of new products, Pakistanis respond opportunely, but in family

[9] Hadith is the term used to denote the collection of sayings of the prophet Muhammad which, with accounts of his daily practice (the Sunna), constitute the major source of guidance for Muslims that supplement the holy book, Quran.

values, gender relations, and political and religious beliefs they tack close to traditions in meaning and function, even if not in form.' (p. 137).

Cultural norms in Pakistan dictate the establishment of joint family systems; when a son is married, the bride is expected to move into her husband's house with his family. Often the married son and his growing family are allocated the upper floor of the house. In three of the six joint families interviewed, a separate kitchen was provided on the first floor for use by the second married couple (Figure **7** and 8); however, in all three cases, it was not being used for daily cooking, as preparing proper meals is considered a joint practice. Where it would be unheard of for a son to live separately from his parents when residing in the same city, cooking and eating meals separately when residing in the same house would also be frowned upon by society, hence the lack of use of the allocated kitchen space, which merely provides symbolic independence.

Figure 7 and Figure 8: Separate kitchen on first floor, not in use. (Left: Interview F; Right: Interview I)

The older generation (those in their 40-60s) in joint families were found to be more conscious of their electricity use compared to the younger generation (10-30 age group):

> "The children mostly don't bother. They are usually too busy in their studies to bother. I am the one who is mostly looking after the house, or if my husband is home, he also does some things. The children are least bothered, even if there is dust, or cobwebs, or even mould, they don't bother!" (Interview B, Mrs Bashir-aged 46)

> "The children don't care much either. For example, in my daughter's washroom, one switch controls six lights, so if there is load-shedding and they aren't working then, when the electricity returns, they remain on after that. If this happens at night, after she has gone to sleep, then all six light bulbs remain on all night long." (Interview H, Mrs Harris-aged 53)

As per traditional norms, the house is considered the primary domain of the female, where most practices are partaken as an assertion to her authority. However, within these middle-class Pakistani households, the role allocations between the genders result in certain dichotomies within the household. For instance, the selection of household appliances and equipment, and the control of thermostat settings for air-conditioning were delegated to the males in nine of ten households. Cleaning and washing were all-female practices in all households. Cooking was predominantly delegated to the females. Hence, even though women are responsible for much of the housework, decision-making is a predominantly male domain:

> "…my father and I, we are out most of the day, so everything in the house is being managed by the ladies of the house. We only come into play where some facilitation is required… In most cases, if an equipment or energy decision has to be made, it comes from us, but what is required, comes from them… These are the decisions that we make…if they want a TV in their room, they would tell us that they want a TV, and we have to give it to them." (Interview F)

Such gendered role attribution was found quite similar to Wilhite's (2008) study of households in southern India, drawing on religious perceptions and social norms of chastity, obedience and self-sacrificing traits as idealised for women. Corroborating these findings, in the midlle-class Pakistani households, females generally displayed a tendency to be more careful in their consumption practices. This is not surprising given the cultural and traditional values of patience and tolerance that are instilled into females since early childhood and are considered an essential component of the female persona. A fitting example of this was seen in Mrs Bashir and Mrs Chishti:

> "…if I am alone in the house, then I don't put it (AC) on for myself solely. I don't feel it's justified for one person only. I just use the fan, making sure hot air doesn't permeate the house, that's it." (Interview B)

> "Yes, I take care very much. Especially in using electricity for my own personal practices. For instance, if someone tells me to use the AC for myself alone in the room, I never do that! I do try not to use any extra for my own self." (Interview C)

However, this trait was more commonly found in the older generation and was not as clearly evident in the younger generation, which portrays the infusion of shifting global trends towards equality and lesser gender disparities within the educated middle-income urban households.

3.5. Conclusions

This research used a practice-based framework for analysing middle-class household electricity consumption in the material and socio-cultural context of a developing country, taking Pakistan as a case study. Based on semi-structured, in-depth interviews and observations in the households, the research highlights the complex interconnected nature of electricity-use in everyday practices that are shaped by the material and socio-cultural arrangements within households and within the wider community. Understanding of electricity-use through 'homely' household practices helped to unfold the otherwise uncertain, unpredictable and therefore 'uncanny' electricity demand.

Materiality in its varying forms (e.g. energy infrastructure, Western influenced homes with open plans and individual electrical appliances) plays an intrinsic role in shaping, and in turn being shaped by, everyday household practices of Pakistani homeowners. Load-shedding and ways to overcome it have made electricity tangible for Pakistani households and influence spatial and temporal arrangements of domestic practices like laundering and ironing. The electricity provision system with its' shortcomings makes electricity tangible and meaningful to homeowners. The Western inspired architectural design and layout of the house, as preferred by the middle-class, determines what practices can be performed and where, and restrict the use of outdoor space due to cultural conventions like privacy - similarly, notions of privacy and gender segregation mean closed curtains and relying on artificial lighting during the day. These energy intensive modernistic prefigurations can conflict with everyday practices. This was seen, for instance, in uninhabitable living room spaces in summer, as their open-plan meant that localised cooling was not an option, and in the disconnect between indoor and outdoor spaces, which serves to transform the materiality as well as sociality of practices.

The interviews suggest that social and cultural structures of society, from the wider social and cultural expectations and acceptance of practices within the neighbourhood community, to religious meanings and ideologies that define the spatiotemporal arrangements of everyday life, and to joint family structures, age disparities and gender roles, have a profound effect on households' daily practices. The socio-cultural context is clearly distinct from Western countries and therefore also the practices themselves differ. This is demonstrated not only in explicit physical forms such as house décor, but in implicit ways, such as the number of appliances deemed 'socially acceptable', and in maintaining the standards and conspicuousness of 'necessary consumption'. Decision-making, purchase of appliances and setting the thermostat were explicitly male dominated in the case study while practices like cooking and cleaning were performed by females. Understanding gender disparities between material purchases in public domain (men) and their domestic use (women) could help to answer broader questions such as why certain policies do not work as intended. The interviews show that women are in a key role in domestic energy management in Pakistan, raising the question of equity (Carlsson-Kanyama and Linden, 2007), since domestic energy saving actions advocated by policies (e.g. load-shedding) have more impact on women than on men.

This study aimed to expand the understanding of how practice theories can conceptualise electricity demand in developing countries. The application of practice theories in the present case study context revealed two aspects; firstly, the current conceptual understandings of practices and potential interventions, based on studies of consumption in the Western countries, cannot be applied as such in developing countries when the performances of practices differ due to socio-cultural aspects like joint family structures and notions of privacy. Secondly, while most energy consumption studies using theories of practice build on Schatzi (1996, 2001) and Reckwitz (2002), adopting their lack of emphasis on socio-economic dimension, this study suggests that Bourdieu's (1984, 1986) notions of class and capital could help to understand better the social differentiation of practices, preferences and norms that can be rooted in notions of socio-economic setting.

Interventions to transform domestic practices in middle-class households in developing countries will be explored in the next stage of the research but three ideas emerged during this study. Firstly, the potential of reconfiguring spatial arrangements could be investigated by studying applications from vernacular architecture, in order to make the middle-class housing typology more compatible with climatic as well as socio-cultural requirements. This would also serve to encourage more passive means of comfort. Secondly, policy frameworks should draw not just from the economic but also social and religious capital as motivation for domestic energy efficiency, as seen in the example of public campaigns of cleanliness in Islamabad. Thirdly, at more general level, policy-makers in developing countries need to take account that 'uncanny' domestic electricity demand is an outcome of mundane, daily routines and consumption practices that are interconnected to the multiple levels of material and social structures that need to be understood in order to formulate an effective and legitimate policy.

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References

Alahdad, Z., 2012. Pakistan's energy sector: From crises to crises- breaking the chain. Pakistan Institute of Development Economics, Islamabad.

Bennett, T., Savage, M., Silva, E., Warde, A., Gayo-Cal, M., Wright, D., 2009. Culture, Class, Distinction. Routledge, London.

Berry, E., 2014. Religion and Sustainability in Global Civil Society: Some Basic Findings from Rio+20. Worldviews 18, 269–288.

Berry, E., 2013. Religious Environmentalism and Environmental Religion in America. Religion Compass 7, 454–466. https://doi.org/10.1111/rec3.12065

Bourdieu, P., 1986. The forms of capital, in: Richardson, J. (Ed.), Handbook of Theory and Research for the Sociology of Education. Greenwood Press, Westport, CT, pp. 241–258. https://doi.org/10.1002/9780470755679.ch15

Bourdieu, P., 1984. Distinction: A Social Critique of the Judgement of Taste, Translated by Richard Nice. Harvard University Press, Cambridge, Massachusetts.

Bourdieu, P., 1977. Outline of a Theory of Practice. Cambridge University Press.

Browne, A.L., 2016. Histories, Trajectories and Patterns of Cleanliness, Energy and Water Consumption: Reflections on China. DEMAND Centre Conference Lancaster.

Darmon, I., Warde, A., 2016. Senses and Sensibilities: Stabilising and Changing Tastes in Cross-National Couples. Food, Culture & Society 19, 705–722. https://doi.org/10.1080/15528014.2016.1243769

EIA, 2016. U.S. Energy Information Administration, Independent Statistics and Analysis. http://www.eia.gov/tools/glossary/index.cfm?id=E [Accessed 23 05 2016].

Flyvbjerg, B., 2006. Five Misunderstandings About Case-Study Research. Qualitative Inquiry 12, 219–245. https://doi.org/10.1177/1077800405284363

Foulds, C., Robison, R.A.V., Macrorie, R., 2017. Energy monitoring as a practice: Investigating use of the iMeasure online energy feedback tool. Energy Policy 104, 194–202. https://doi.org/10.1016/j.enpol.2017.01.055

Freud, S., 1919. The "Uncanny," in: Freud, S., Strachey, J., Freud, A., Strachey, A., Tyson, A. (Eds.), The Standard Edition of the Complete Psychological Works of Sigmund Freud. An Infantile Neurosis and Other Works. Hogarth Press, London, pp. 217–256.

Galvin, R., 2015. How many interviews are enough? Do qualitative interviews in building energy consumption research produce reliable knowledge? Journal of Building Engineering 1, 2–12. https://doi.org/10.1016/j.jobe.2014.12.001

Galvin, R., Sunikka-Blank, M., 2016. Schatzkian practice theory and energy consumption research: Time for some philosophical spring cleaning? Energy Research & Social Science 22, 63–68. https://doi.org/10.1016/j.erss.2016.08.021

Giddens, A., 1984. The Constitution of Society: Outline of the Theory of Structuration. University of California Press.

Gram-Hanssen, K., 2014. New needs for better understanding of household's energy consumption – behaviour, lifestyle or practices? Architectural Engineering and Design Management 10, 91–107. https://doi.org/10.1080/17452007.2013.837251

Gram-Hanssen, K., 2011. Understanding change and continuity in residential energy consumption. Journal of Consumer Culture 11, 61–78. https://doi.org/10.1177/1469540510391725

Gram-Hanssen, K., 2010. Residential heat comfort practices: understanding users. Building Research & Information 38, 175–186. https://doi.org/10.1080/09613210903541527

Gram-Hanssen, K., 2008. Consuming technologies – developing routines. Journal of Cleaner Production 16, 1181–1189. https://doi.org/10.1016/j.jclepro.2007.08.006

Halkier, B., Jensen, I., 2011. Doing 'healthier' food in everyday life? A qualitative study of how Pakistani Danes handle nutritional communication. Critical Public Health 21, 471–483. https://doi.org/10.1080/09581596.2011.594873

Halkier, B., Katz-Gerro, T., Martens, L., 2011. Applying practice theory to the study of consumption: Theoretical and methodological considerations. Journal of Consumer Culture 11, 3–13. https://doi.org/10.1177/1469540510391765

Hand, M., Shove, E., Southerton, D., 2005. Explaining showering: a discussion of the material, conventional, and temporal dimensions of practice. Sociological Research Online 10. https://doi.org/10.5153/sro.1100

HDIP, 2015. Pakistan Energy Yearbook 2014. Islamabad: Ministry of Petroleum and Natural Resources, Government of Pakistan.

HIES, 2015. Household Integrated Economic Survey (HIES) 2013-14, Islamabad: Pakistan Bureau of Statistics.

http://www.pbs.gov.pk/sites/default/files//pslm/publications/hies2013_14/hies_complete_report_2013_14.pdf. [Accessed on 17 06 16]

Higginson, S., McKenna, E., Hargreaves, T., Chilvers, J., Thomson, M., 2015. Diagramming social practice theory: An interdisciplinary experiment exploring practices as networks. Indoor and Built Environment 24, 950–969. https://doi.org/10.1177/1420326X15603439

Karakosta, C., Askounis, D., 2010. Developing countries' energy needs and priorities under a sustainable development perspective: A linguistic decision support approach. Energy for Sustainable Development 14, 330–338. https://doi.org/10.1016/j.esd.2010.07.008

Karvonen, A., 2013. Towards systemic domestic retrofit: a social practices approach. Building Research & Information 41, 563–574. https://doi.org/10.1080/09613218.2013.805298

Kreft, S., Eckstein, D., Junghans, L., Kerestan, C., Hagen, U., 2015. Global Climate Risk Index 2015: Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2013 and 1994 to 2013. GermanWatch e.V., German Federal Ministry for Economic Cooperation and Development (BMZ), Berlin.

Kuijer, L., Jong, A. de, Eijk, D. van, 2013. Practices as a unit of design: An exploration of theoretical guidelines in a study on bathing. ACM Transactions on Computer-Human Interaction 20, 1–22. https://doi.org/10.1145/2493382

Maller, C., 2011. Practices involving energy and water consumption in migrant households, in: Newton, P. (Ed.), Urban Consumption. CSIRO Publishing, Collingwood, Australia, pp. 237–250. https://doi.org/10.1071/9780643103511

Maller, C., Horne, R., Dalton, T., 2012. Green Renovations: Intersections of Daily Routines, Housing Aspirations and Narratives of Environmental Sustainability. Housing, Theory and Society 29, 255–275. https://doi.org/10.1080/14036096.2011.606332

Matsuhashi, N., Kuijer, L., De Jong, A.M., 2009. A culture-inspired approach to gaining insights for designing sustainable practices, in: EcoDesign 2009. Presented at the Proceedings of the 6th International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Japan Society of Mechanical Engineers, Sapporo, Japan.

Mumtaz, K.K., 1985. A case for indigenous development, in: Powell, R. (Ed.), Regionalism in Architecture, Exploring Architecture in Islamic Cultures 2. Published for the Aga Khan Award for Architecture, 1985 by Concept Media, Singapore, pp. 55–57.

Nicol, J.F., Humphreys, M.A., 2002. Adaptive thermal comfort and sustainable thermal standards for buildings. Energy and Buildings 34, 563–572. https://doi.org/10.1016/S0378-7788(02)00006-3

Palm, J., Reindl, K., 2016. Understanding energy efficiency in Swedish residential building renovation: A practice theory approach. Energy Research & Social Science 11, 247–255. https://doi.org/10.1016/j.erss.2015.11.006

Palmer, M., Finlay, V., 2003. Faith in Conservation: New Approaches to Religions and the Environment, 1st ed, (Directions in Development - Human Development). World Bank Publications, Washington, D.C.

Pierce, J., Paulos, E., 2010. Materializing energy, in: Proceedings of the 8th ACM Conference on Designing Interactive Systems. ACM, pp. 113–122.

Powells, G., Bulkeley, H., Bell, S., Judson, E., 2014. Peak electricity demand and the flexibility of everyday life. Geoforum 55, 43–52. https://doi.org/10.1016/j.geoforum.2014.04.014

Purhonen, S., Gronow, J., Heikkilä, R., Kahma, N., Rahkonen, K., Toikka, A., 2014. Suomalainen maku: Kulttuuripääoma, kulutus ja elämäntyylien sosiaalinen eriytyminen [The Finnish Taste: Cultural Capital, Consumption and the Social Differentiation of Lifestyles]. Gaudeamus Helsinki University Press, Helsinki.

Qadeer, M., 2006. Pakistan: Social and cultural transformations in a Muslim nation. Routledge, Abingdon, Oxon. https://doi.org/10.4324/9780203099681

Reckwitz, A., 2012. Affective spaces: a praxeological outlook. Rethinking History 16, 241–258. https://doi.org/10.1080/13642529.2012.681193

Reckwitz, A., 2002. Toward a theory of social practices: a development in culturalist theorizing. European journal of social theory 5, 243–263.

Rinkinen, J., Jalas, M., Shove, E., 2015. Object Relations in Accounts of Everyday Life. Sociology 49, 870–885. https://doi.org/10.1177/0038038515577910

Rinkinen, J., Smits, M., 2016. Conceptualising conjunctions: Understanding change in energy related practices in urban Southeast Asia, in: What Energy Is for: The Making and Dynamics of Demand. Presented at the DEMAND Centre Conference, 13-15 April, DEMAND, Lancaster, p. 9.

Røpke, I., Gram-Hanssen, K., Jensen, J.O., 2008. Households' ICT use in an energy perspective, in: Published in Bartolomeo Sapio et Al. (Eds.): The Good, the Bad and the Unexpected: The User and the Future of Information and Communication Technologies. Presented at the Proceedings from a conference organized by COST Action 298 "Participation in the Broadband Society," COST Office, Brussels, Moscow 23-25 May 2007, pp. 595–611.

Sahakian, M., 2014. Keeping Cool in Southeast Asia: Energy Consumption and Urban Air-Conditioning. Palgrave Macmillan UK.

Savage, M., Devine, F., Cunningham, N., Taylor, M., Li, Y., Hjellbrekke, J., Le Roux, B., Friedman, S., Miles, A., 2013. A New Model of Social Class? Findings from the BBC's Great British Class Survey Experiment. Sociology 47, 219–250. https://doi.org/10.1177/0038038513481128

Schatzki, T.R., 2011. Where the action is (on large social phenomena such as sociotechnical regimes). Sustainable Practices Research Group, Working Paper 1.

Schatzki, T.R., 2002. The site of the social: A philosophical account of the constitution of social Life and change. Penn State Press.

Schatzki, T.R., 2001. Introduction, in: Schatzki, T.R., Cetina, K.K., Savigny, E. von (Eds.), The Practice Turn in Contemporary Theory. Routledge (Taylor & Francis Group), New York, pp. 1–14.

Schatzki, T.R., 1997. Practices and actions a Wittgensteinian critique of Bourdieu and Giddens. Philosophy of the social sciences 27, 283–308.

Schatzki, T.R., 1996. Social Practices: A Wittgensteinian Approach to Human Activity and the Social. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511527470

Schatzki, T.R., 1990. Do Social Structures Govern Action? Midwest Studies in Philosophy 15, 280–295.

Schmidt, S., Weigt, H., 2015. Interdisciplinary energy research and energy consumption: What, why, and how? Energy Research & Social Science 10, 206–219. https://doi.org/10.1016/j.erss.2015.08.001

Shaikh, H., 2016. Housing inequality in Pakistan: The case of affordable housing, Lahore: International Growth Centre (IGC). http://cdpr.org.pk/wp-content/uploads/2016/02/IGC-Pakistan-2016-Policy-note.pdf [Accessed 18 09 2016]

Shove, E., 2014. Putting practice into policy: reconfiguring questions of consumption and climate change. Contemporary Social Science 9, 415–429. https://doi.org/10.1080/21582041.2012.692484

Shove, E., 2010. Beyond the ABC: Climate Change Policy and Theories of Social Change. Environment and Planning A 42, 1273–1285. https://doi.org/10.1068/a42282

Shove, E., Pantzar, M., 2005. Consumers, producers and practices: understanding the invention and reinvention of Nordic walking. Journal of consumer culture 5, 43–64.

Shove, E., Pantzar, M., Watson, M., 2012. The Dynamics of Social Practice: Everyday Life and how it Changes. SAGE Publications, London.

Shove, E., Walker, G., 2014. What Is Energy For? Social Practice and Energy Demand. Theory, Culture & Society 31, 41–58. https://doi.org/10.1177/0263276414536746

Smits, M., 2015. Southeast Asian Energy Transitions: Between Modernity and Sustainability. Ashgate Publishing, Ltd., Surrey, England ; Burlington, VT.

Smits, M., Rinkinen, J., 2016. Unpacking convergence/divergence: comparing elements, practices and conjunctions of middle-class households in Bangkok and Hanoi. Presented at the DEMAND.

Strauss, A., Corbin, J., 1998. Basics of qualitative research: Techniques and procedures for developing grounded theory, 2nd ed., Basics of qualitative research: Techniques and procedures for developing grounded theory, 2nd ed. Sage Publications, Inc, Thousand Oaks, CA, US.

Strengers, Y., 2013. Smart Energy Technologies in Everyday Life: Smart Utopia?, 1st ed. 2013 edition. ed. Palgrave Macmillan, London.

Strengers, Y., 2012. Peak electricity demand and social practice theories: Reframing the role of change agents in the energy sector. Energy Policy 44, 226–234. https://doi.org/10.1016/j.enpol.2012.01.046

Vidler, A., 1992. The Architectural Uncanny: Essays in the Modern Unhomely. MIT Press, London.

Warde, A., 2005. Consumption and theories of practice. Journal of consumer culture 5, 131–153.

Warde, A., Southerton, D., 2012. The Habits of Consumption. Helsinki Collegium of Advanced Studies.

Watson, M., Shove, E., 2005. Doing it yourself? Products, competence and meaning in the practices of DIY, in: "Rethinking Inequalities." Presented at the Proceedings of the 7th conference of the European Sociological Association. 9-12 September 2005, ESA, Torun, Poland.

White, L., 1967. The Historical Roots of Our Ecologic Crisis. Science 155, 1203. https://doi.org/10.1126/science.155.3767.1203

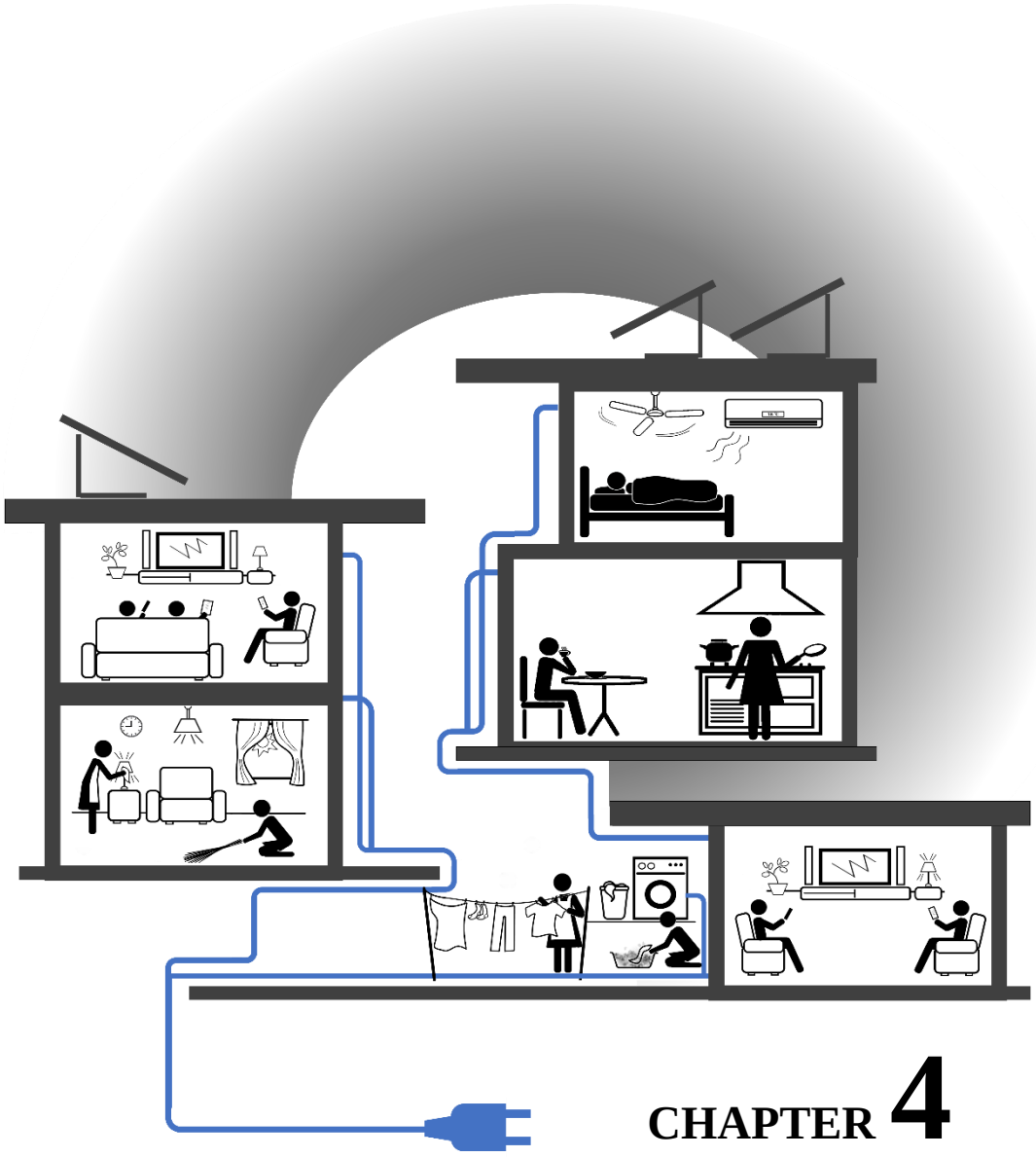
Wilhite, H., 2008. Consumption and the transformation of everyday life: a view from South India. Palgrave Macmillan, Hampshire.

Wilhite, H., Lutzenhiser, L., 1999. Social Loading and Sustainable Consumption. ACR North American Advances NA-26.

Wilhite, H., Nakagami, H., Masuda, T., Yamaga, Y., Haneda, H., 1996. A cross-cultural analysis of household energy use behaviour in Japan and Norway. Energy policy 24, 795–803.

Wolfram, C., Shelef, O., Gertler, P., 2012. How Will Energy Demand Develop in the Developing World? The Journal of Economic Perspectives 26, 119–138.

Yin, R.K., 2014. Case Study Research: Design and Methods, 5th ed. SAGE Publications, California, US.



CHAPTER 4

4. Historical trajectory of spatial layouts and household practices

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Abstract

This paper seeks to address the gap in current studies of domestic energy-use in countries in the Global South from a socio-technical perspective. It explores a trajectory of domestic spatial layouts and accompanying household practices over the last century in Lahore, Pakistan. This helps identify various nexuses of practice-spatial arrangements of urban housing that have emerged, persisted and transformed over time, giving rise to unsustainable levels of electricity consumption in middle-class households. A mixed-method approach was adopted for collecting data including a review of archival documents, building regulations, house plans, case-studies, oral history narratives and expert interviews. This analysis reveals three key themes as central to explaining increasing household electricity demand: a shift from outdoor to indoor activities, transformation from inward- to outward-oriented design and a spatial dispersion of practices. The study suggests that understanding longitudinal dynamics of practice-arrangements can help identify and prevent normalisation of unsustainable configurations that gradually become embedded in social structures and practices.

Contemporary standards are likely to prefigure higher demands for electricity because of increased consumption and specification of spaces, culturally ill-suited indoor and outdoor configurations, unquestioned reliance on electricity and neglected use of outdoor space. Though confined to a single case, this study has broader methodological applicability and implications for other countries in the Global South.

Key words: Domestic buildings, Global South, electricity consumption, spatial design, social practices, households.

4.1. Introduction

Energy consumed in the building sector accounts for just over 20% of total global consumption. In the Global South, this consumption is predicted to grow nearly three times the rate for developed nations by 2040 (EIA, 2016). By 2030, more than 80% of the middle-class globally is projected to be from the Global South, accounting for 70% of total energy consumption (UNDP, 2013). Yet most energy policies in countries of the South, like Pakistan, tend to focus on energy generation while neglecting demand management (Alahdad, 2012). This becomes more evident when reviewing national housing policies as they prove inadequate in dealing with the current housing shortage. In addition, they fail to consider the energy efficiency of existing housing (National Housing Policy Pakistan, 2001; Tiwari and Rao, 2016).

During the first decade of the 21st century in Pakistan, middle-class households, defined as having daily per capita expenditures of US$2-US$10 (in 2005 purchasing power parity dollars[10]), grew from 32% to 55% of the total population. The middle-class is expected to contribute to 90% of the increase in national energy consumption (Ghani, 2014). Pakistan's housing shortage is approximately 10 million units and the deficit is growing, particularly in urban areas (World Bank, 2017).

A socio-technical analysis of energy consumption can provide an in-depth and nuanced understanding of what this consumption is for and how it has come about, as has been proposed by practice theorists (see e.g. Warde, 2005; Gram-Hanssen, 2008; Shove, 2010; Strengers, 2010; Halkier et al., 2011; Shove and Walker, 2014). Growing energy demand and comfort standards of middle-class households in the Global South have been the subject of recent study (Wilhite, 2008a; Smits, 2011; Sahakian, 2014; Browne, 2016; Hansen et al., 2016). However, there is limited research on housing spatial arrangements and how these interlink with everyday practices that can lead to energy-intensive configurations. Furthermore, a detailed analysis of how and why this consumption has changed over

[10] The conversion rate for purchasing power parity (PPP) 2005 dollars was Rs. 17.60 in 2001-02, Rs. 41.50 in 2010-11, and Rs 50 in 2013-14. Hence, middle-class was defined to be monthly expenditures (for a 6-person household) of Rs. 6,400 -32,100 in 2002, and Rs. 15,100 to Rs. 75,700 in 2011. For further description of middle-class, see Ghani (2014).

time requires a longer temporal dimension (Calwell, 2010). Instead of considering buildings simply as grounds for technological efficiency in construction and appliances, there is a need to view buildings as the material counterparts of competing social practices (Guy and Shove, 2000). Unsustainable practice-arrangements need to be challenged instead of being reproduced (Gram-Hanssen, 2014a). Hence, this research adopts a socio-material approach to understanding energy demand in middle-class households in Lahore, the second-largest urban centre in Pakistan, with a population of 11.13 million. It analyses the coevolution of everyday practices of homeowners and the associated material and spatial arrangements to target both *efficiency* and *sufficiency* in urban households' energy consumption. By applying Schatzki's (2010a) conceptualisation of 'practice-arrangement bundles' to the emergence, persistence and transformation of urban housing, this paper seeks to unfold links between spatial layouts and household practices in middle class households in Lahore.

This paper is structured as follows: Section 4.2 presents the methodology and the review of spatial evolution of middle-class houses in Lahore. Key findings are presented in section 4.3. Conclusions are made in section 4.4.

4.2. Methodology

4.2.1. Social practices and spatial structures

Practice theorists have frequently focused on household practices in empirical energy-use studies (Hand et al., 2005; Ropke et al., 2007; Gram-Hanssen, 2009; Halkier and Jensen, 2011a; Judson and Maller, 2014; Walker et al., 2014 among others); however, the position of materiality in practices has been much debated (Hand et al., 2007; Kuijer and Watson, 2017; Rinkinen et al., 2015; Shove, 2016), especially with regards to buildings as infrastructure in practice formations. Adopting a socio-technical approach to interpret architecture, Gieryn (2002) suggests that buildings are 'objects of (re)interpretation, narration and representation' (p. 35) that present a duality of structure and agency that can only be understood by taking a combined account of Giddens' and Bourdieu's theorisations; both acknowledge the significance of the built environment in relation to social order. Giddens (1984a, 1993) emphasises the importance of material spaces not only in providing contextuality to activity time-spaces but also in constituting and reproducing them. Taking a step further, Bourdieu (e.g. Bourdieu, 1996, 1981, 1970) acknowledges structuration of the built environment that mediates social practices and dictates cultural distinctions. For example, his spatial analysis of the Kabyle House as structuring and reproducing gendered practices in a Berber society (Bourdieu, 1970).

Building on Giddens' and Bourdieu's theories, Schatzki (2010a) presents his theorisation of social order as a plenum of practices and material arrangement bundles. Material arrangements refer to the set of interconnected material entities including humans, artefacts, organisms and things of nature.

The bundling of practices and material arrangements occurs in that (1) practices affect, alter, give meaning to, and are inseparable from arrangements; (2) arrangements channel, prefigure and facilitate practices (Schatzki, 2011). Physical configuration of the house, therefore, presents an example of material spatial arrangements that structure and mediate various household practices. New bundles are formed by material innovations or intentional redesign of the built environment to accommodate ever-changing practices. The history of domestic architecture thus provides evidence of how homes can have emergent consequences for trajectories of practice nexuses and resulting electricity demand (Kuijer and Watson, 2017).

This paper applies Schatzki's theorisation of practice-arrangement nexuses to the unfolding trajectories of middle-class household practices and spatial layouts to better conceptualise electricity consumption. Two concepts from Schatzki's practice theorisation will be adopted: historicity and prefiguration. Historicity (Schatzki, 2010b, p. 201) refers to existence of the past in the present. For Schatzki (2010b), the past inhabits the present; what people do and how they react to things is circumscribed through practice memory, oriented by filling out past dimension of temporality and publicly manifested through bodily training and practical understandings, by or through the past. The second concept adopted is prefiguration (Schatzki, 2010a, p. 139)- a type of relation between practices and arrangements. Material arrangements can prefigure practices through possible pathways of action on an indefinite set of registers, such as easy or difficult, obvious or obscure, expensive or cheap. According to Schatzki, past, present and future activities coexist so long as a person *acts*. In the present study, these two concepts of *past in the present* (historicity) and *present in the future* (prefiguration) will help configure coevolution of practice-arrangement bundles in this study's context.

4.2.2. Method

A mixed-method approach was adopted for collecting data. Archival data on urban planning and building regulations in Lahore were obtained from relevant authorities (e.g. Annual reports of the Lahore Improvement Trust (1936-1950) from the Punjab Archives, and building byelaws from Lahore Development Authority Head Office). Typical house plans from different architectural periods were obtained to develop a timeline of middle-class house spatial layouts.

Five case-study houses were selected to represent relevant housing typologies from different periods and were visited and photographed. They were deemed to be good representatives of a specific architectural period in terms of spatial configuration and location; also, they had been occupied by the same family for many generations (e.g. case-study 1 housed the family's seventh generation). This enabled enquiry on how spaces, and their use, have adapted to changing needs over time. The homeowners of each case-study house were questioned about daily household practices of their grandparents and parents who had lived in the same house, as well as asked to give information about

their own current routines and practices. Homeowners were also questioned about how their electricity use had changed over time, which included listing their appliances. Some of the older interviewees (e.g. Interviewee H7 and H9) provided rich narratives on how electricity consumption had changed drastically during their lifetime. This was corroborated with statistical data on electric appliance availability and ownership in Pakistan (see Table 8).

In addition to case-studies, oral history interviews with older residents of Lahore and a focus group discussion with seven middle-aged housewives were conducted (see Table 6). Fourteen semi-structured interviews with field experts in architecture and town-planning, history and social-sciences were conducted to understand changes in over-arching socio-cultural, political and environmental structures in Lahore.

Individual semi-structured interviews (conducted in 2017-2018) ranged from 60-140 minutes. All interviews were recorded, translated from Urdu to English, and transcribed. Interview findings were coded and analysed using NVivo 11 (a type of CAQDAS- Computer Aided Qualitative Data Analysis Software). Finally, major themes were identified within the context of practice-arrangement trajectories.

Data was collected on the coevolution of spatial layouts and household practices for the last century. Electricity was first introduced in Lahore in 1912 and became more widespread in the domestic sector by the late 1920s. Hence, analysis of the last century gives account of how changes in practice-arrangements were affected by the changing role of electricity in households. Homeowners were questioned about their practices related to housekeeping, comfort (cooling and ventilation)[11], cleanliness (house cleaning, laundering, personal hygiene), cooking, lighting, sleeping, eating, recreation/entertainment and communication.

Historical trajectories of household practice-arrangements in Lahore presented in this paper are in no way comprehensive. As Schatzki (2013) points out, social life is too complex and diverse to construct general explanatory schemas of practice-arrangement transitions. Architecture in Lahore is formed of disjointed ideologies and mutually exclusive paradigms (Khan, 1983), consisting of a matrix of multiple urban and architectural styles. As such, historical analysis is limited to mainstream architecture that dominated domestic spatial design. In doing so, the lenses of historicity and prefiguration help to draw out key themes, albeit with certain generalisations unavoidable with a project of such magnitude.

[11] Heating practices did not come up during the interviews in relation to electricity consumption, since gas is conventionally used for heating and is normally only required for a few months of the year, whereas the bulk of electricity consumption is needed for space cooling annually.

Table 6: Details of interviewees and case-study houses

No.	Interviewee pseudonym	Year of birth	Residence in Lahore: Housing Scheme	Residence in Lahore: House details	Years in residence	Houses visited as case-studies
	Homeowner Interviews					
H1	Hafiz	1966	near Bhatti Gate, Walled City of Lahore	33marla[1]- built 1700s. Traditional courtyard *haveli*	1966 - present	Case-study 1 (House A: Fig.9)
H2	Faheem & Mrs	1950s	Krishan Nagar	9marla- built 1935	1950s - present	Case-study 2
H3	Ejaz & Mrs	1982	Model Town Society	6kanal[2] – built 1937. Bungalow-style hybrid house	1982 - present	Case-study 3 (House C: Fig.9)
H4	Samina	1942	Gulberg II	4kanal, built 1962. Bungalow-style hybrid house under post-independence LIT byelaws	1962 - 1982	Case-study 4 (House D: Fig.9)
H5	Ghazal	1959	Baghbanpura Lahore	N/A, built-1930s	1959 - 1985	---
			Defense Housing Authority	1kanal- built 1992	1992 - present	Case-study 5
H6	Aliya	1960	Ichhra	4kanal- built 1932	1960 - 1989	---
			Shah Jamal	4kanal- built 1989	1989 - 1997	---
			Cavalry Ground	10marla- built 1997	1997 - present	---
H7	Babar	1927	near Bhatti Gate, Walled City of Lahore	37marla- built 1850s	1927 - 1960	---
			Shadman	2kanal- built 1960	1960 - 1988	---
			New Garden Town	1kanal- built 1988	1988 - present	---
H8	Seerat	1958	near Delhi Gate, Walled City of Lahore	47marla- built 1850s	1975 - present	---
H9	Dilawar	1927	Misri Shah	N/A, built 1939	1939 - 1945	---
			Samnabad	2kanal- built 1967	1967 - 1998	---
			Defense Housing Authority	1kanal- built 1998	1998 - present	---
	Focus group discussion					
FGD	7 House-wives	1950-1975	Residents of Lahore from an up-scale contemporary housing scheme, Defence Housing Authority.			

[1] marla: traditional unit of area measurement. 1marla = 25.29 sqm
[2] kanal: traditional unit of area measurement. 1kanal = 505.86 sqm

Furthermore, accessing past and present private everyday household practices is empirically challenging, requiring a level of detail only possible through a social constructivist enquiry (Halkier and Jensen, 2011a; Schatzki, 2006) with a case-study approach (Bent Flyvbjerg, 2006). Oral history accounts as secondary sources can be biased and incomplete, resulting in partial accounts of historical activities. However, this perceived disadvantage compared to other qualitative methods, e.g. participant observation or analysis of biographies, is contested as these methods are prone to similar biases of interpretation and selective description (Thompson, 1972; Atkinson and Coffey, 2003; Forsey, 2010; Halkier, 2017). Efforts were made to overcome such limitations by ensuring triangulation of data obtained through visits of case-study houses as a means of observing 'objectified history' (Bourdieu, 1981), as the interviewees' experiences are anchored by the prevailing physical

manifestations of past 'lived space' (Schatzki, 2010b, p. 14) and, occasionally, through old photographs of the house and household activities. This data was further substantiated through interviews with historians and other experts, and detailed study of literature and archival documents. Further, the objective of the analysis was not to make statistical generalisations, but to develop a social constructivist (Halkier and Jensen, 2011a) understanding of patterns enacted in practice-arrangements over time that have resulted in increasing electricity demand of middle-class households in Lahore.

4.2.3. Evolution of house spatial layout in Lahore

Figure 9 shows the spatial evolution of houses over the last century with six houses that represent mainstream architecture of middle-class housing in Lahore at the time. The spatial evolution of houses can be seen through the transformation of the introverted traditional house (House A: Figure 9) into British bungalow-style house with its outward configuration of open spaces (House C: Figure 9) and finally, to post-independence 'modernistic' prefiguration of open-plan indoor spaces and restricted outdoor spaces (House F: Figure 9).

The 'typical' (Glover, 2008, p. 103) vernacular house of Lahore preceding colonisation was a central courtyard house, expanding outward organically, with outer walls extending to the boundary lines. Edwards et al. (2006) contend that in traditional housing[12], the central courtyard acted as a mediator between inside and outside spaces. These houses could best be described as 'introverted' (Petherbridge, 1978, p. 197), conceived from the inside-out with layers of social accessibility. At the urban level, these houses would form an organic, maze-like urban fabric with inclusive mixed-use development (Glover, 2008). Similar characteristics are found today in old *havelis*[13] of the Walled City of Lahore (House A: Figure 9).

During colonial occupation in late nineteenth century, developments for the ruling British class departed from tradition, both at the house and urban scale. Under colonisation, planning in Lahore followed a more rigid, gridiron pattern of development, as seen in the British Cantonment and Civil lines, leading to an outward-oriented house layout (Edwards et al., 2006). While Indian customs dictated more fluid use of domestic spaces, British requirements necessitated different house designs and layouts (Shorto, 2007). Thus, a new housing typology *bungalow*[14] (House B: Figure 9) emerged,

[12] Traditional housing here depicts the courtyard house typology dominant in the historical cities of the Islamic World. Özkan, in (Edwards et al., 2006), contends that the courtyard as a house plan type existed extensively in history from China to Morocco. and became a generic typology in hot, arid, climatic landscapes (p. xiv). Similarly, Pramar, in (Pramar, 2005), traces the various developments in the traditional houses of India, starting from the Indus Valley Civilisation to the colonial influences under the British Raj.

[13] *Haveli* is a traditional large townhouse or mansion in South India.

[14] According to King (1984), the word '*bungalow*' was derived from the Hindi or Marhatti *Bangla*, meaning 'of or belonging to Bengal'.

depicting a 'social and cultural (re)organisation of the building form.' (King, 1984, p. 14). Large bungalow houses, contrasting with attached houses of the Walled City, became 'a symbol of power' (Khan, 1983, p. 70) in the emergence of a colonised space and society. Outward orientation towards the street fixated internal layouts of rooms. Additionally, spaces were designed for distinct functions, introducing spaces like dining and dressing rooms to the local architectural vocabulary. These features were later replicated in native housing developments (House C: Figure 9).

By early 20th century, the inward-oriented traditional house and the freestanding detached British bungalow were propelled into an 'architectonic merger' (Khan, 1983, p. 25). Parallel to colonial notions of comfort and ideals of appropriate housing, another force driving change was the emerging colonial discourse on public health and sanitation (Glover, 2008). During this period, alterations to local housing focused on improving access to air and light. Hence, New Indigenous Communities (NIC) developed under Lahore Municipal Corporation (LMC) were planned with broad gridiron streets and multi-storey row houses (e.g. developments of Krishan Nagar, Gowal Mandi and Ram Nagar). Although these settlements differed from traditional settlements in their overall siting, street patterns and density, internal spatial layouts and functions remained unchanged (Glover, 2008), with the house centred around an inner courtyard, extending to plot lines.

A key milestone in urban planning in Lahore was the development of Model Town Society in 1921. Based on Ebenezer Howard's Garden City concept (Khan, 1994), the development was divided into clear zones for residential, commercial and public amenities. This marked a clear shift from inclusive (mixed-use) to exclusive zoning in local planning. This set the precedent for post-independence colonially-inspired housing development. Compared to vernacular, the house design now reversed in on itself; covered construction in the centre surrounded by open spaces (House C: Figure 9). Yet functional use remained fairly embedded in tradition persisting through social norms of joint family structures, giving rise to what Khan refers to as 'indigenous bungalow' (1983, p. 87). House fronts reflected colonial ideologies (e.g. in formal drawing room spaces), while the back remained traditional in use (House C and D: Figure 9).

In 1936, Lahore Improvement Trust (LIT), the first institutional planning body, initiated development under stringent colonial-style restrictions of site division into building plots and streets as well as building types in an exclusive zoning format (LIT, 1941). After the dissolution of LIT and subsequent formation of Lahore Development Authority (LDA) in 1975, private and

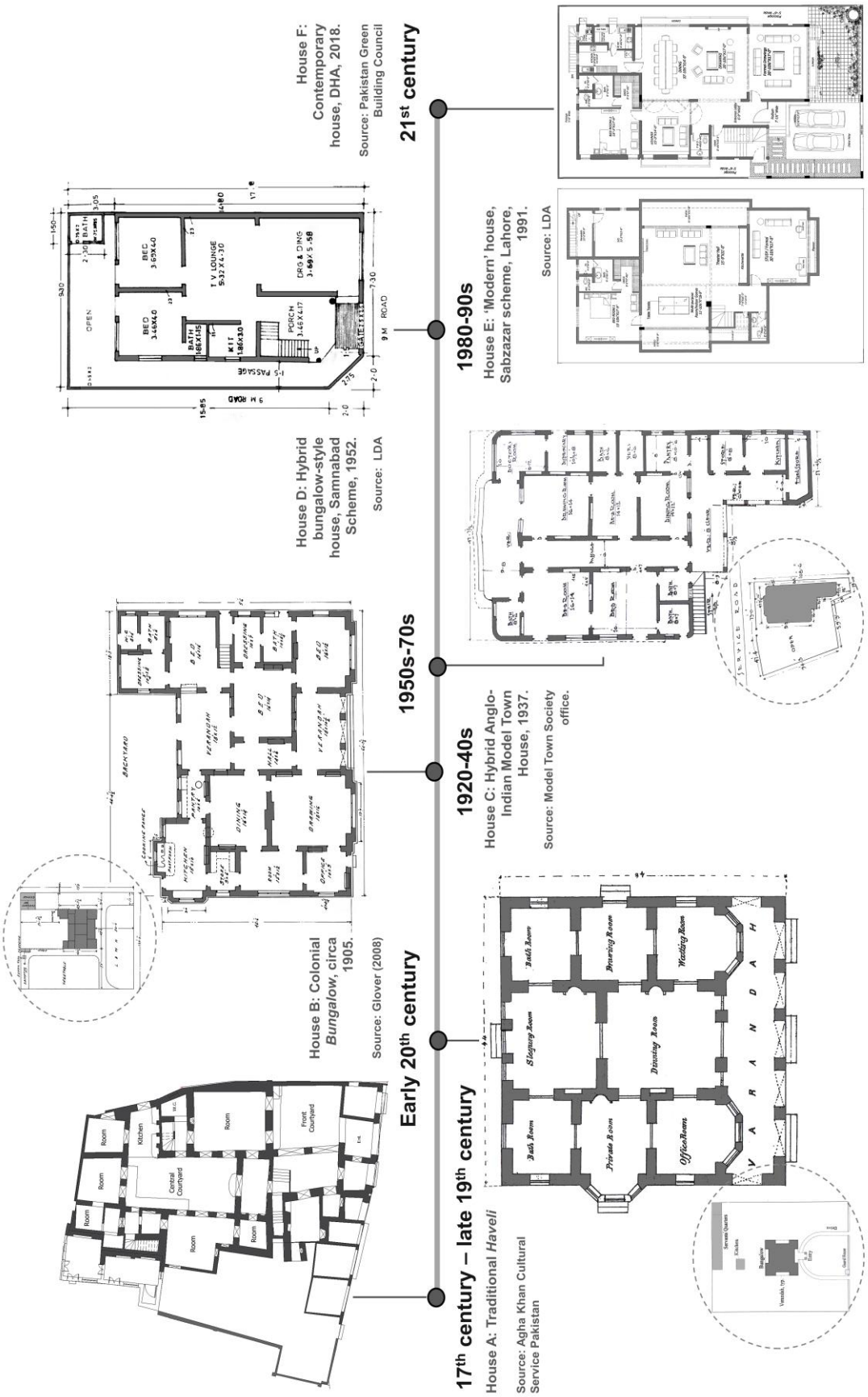

Figure 9: Timeline showing evolution of house spatial layout of Lahore

Table 7: Lahore Building Regulations; LIT (1935-1950); LDA (1976-present)

Building Regulations	**LIT**	**LDA**						
	1940-41[1]	**1976**[1]	**1984**[2]	**1997**	**2002-4**	**2005-6**	**2007**[3]	**2014**
2kanal+ (*changed to "32marlas and above" in 2005*); LIT - *Bungalow* schemes: 4kanal +								
House Line[4] (min)	20ft	20ft	20ft	20ft	20ft	20ft	20ft	20ft
Space (rear) (min)	15ft	15ft	10ft*	10ft	10ft	10ft	10ft	10ft
Space (sides) (min)	5ft	10ft x2	10ftx2	10ftx2	10ftx2	10ft	10ft	10ft
Area covered (%) (max)	30%	50%	55%	55%	_*	55%	60%	60%
Floor-to-area ratio (max)	N/A	1:1.25	1:1.25	1:1.25	_	1:1.25	1:1.3	1:1.3
<2kanal (*changed to "30marlas - 2kanals" in 2007);* LIT - *Abadi* schemes: 1kanal or less								
House Line (min)	20ft	10ft	_	_	_	_	10ft	10ft
Space (rear) (min)	15ft	10ft	_	_	_	_	7ft	7ft
Space (sides) (min)	5ftx1	5ftx1	_	_	_	_	5ftx1	5ftx1
Area covered (%) (max)	50%	60%	_	_	_	_	65%	65%
Floor-to-area ratio (max)	N/A	1:1.25	_	_	_	_	1:1.4	1:1.4
1kanal – < 2kanal (*changed to "10marlas – 30marlas" in 2007*)								
House Line (min)	_	_	10ft	10ft	10ft	10ft	10ft	10ft
Space (rear) (min)	_	_	10ft	10ft	10ft	10ft	7ft	7ft
Space (sides) (min)	_	_	5ftx1	5ftx1	5ftx1	5ftx1	5ftx1	5ftx1
Area covered (%) (max)	_	_	60%	60%	60%	60%	65%	65%
Floor-to-area ratio (max)	_	_	1:1.25	1:1.25	1:1.25	1:1.25	1:1.4	1:1.4
10marlas – < 1kanal								
House Line (min)	_	_	10ft	10ft	10ft	10ft	5ft	5ft
Space (rear) (min)	_	_	10ft	10ft	7ft	7ft	5ft	5ft
Space (sides) (min)	_	_	5ftx1	5ftx1	5ftx1	5ftx1	5ftx1	5ftx1
Area covered (%) (max)	_	_	65%	65%	65%	65%	70%	70%
Floor-to-area ratio (max)	_	_	1:1.3	1:1.3	1:1.3	1:1.3	1:1.5	1:1.5
< 10marlas								
House Line (min)	_	_	Building Line[4]	5ft	5ft	5ft	5ft	5ft
Space (rear) (min)	_	_	10ft	5ft	5ft	N/A	5ft	5ft
Space (sides) (min)	_	_	5ftx1	0ft	0ft	0ft	5ftx1	5ftx1
Area covered (%) (max)	_	_	70%	70%	N/A	70%	80%	80%
Floor-to-area ratio (max)	_	_	1:1.4	1:1.4	N/A	1:1.4	1:1.6	1:1.6
< 7marlas								
House Line (min)	_	_	Building Line	5ft	5ft	N/A	_	_
Space (rear) (min)	_	_	10ft	5ft	0ft	N/A	_	_
Space (sides) (min)	_	_	0ft	0ft	0ft	N/A	_	_
Area covered (%) (max)	_	_	75%	75%	N/A	75%	_	_
Floor-to-area ratio (max)	_	_	1:1.5	1:1.5	N/A	1:1.5	_	_
< 5marlas								
House Line (min)	_	_	_	_	_	_	5ft	5ft
Space (rear) (min)	_	_	_	_	_	_	0ft	0ft
Space (sides) (min)	_	_	_	_	_	_	0ft	0ft
Area covered (%) (max)	_	_	_	_	_	_	85%	85%
Floor-to-area ratio (max)	_	_	_	_	_	_	1:2	1:2

[1] Byelaws categorised into two plot sizes
[2] Additional plot size categories introduced
[3] 5Marlas category introduced
[4] House/Building line is defined as line beyond which the outer face of any building except compound wall, may not project in the direction of any street, existing or proposed* Dashed cell indicates sub-division not existing in byelaws. Grey cell indicates change from previous byelaws

military development bodies started to engage in wide-scale development in the city outskirts. An overview of subsequent building regulations published during this period reveals some critical changes (Table 7); plot sizes gradually decreased over time and covered area on plots subsequently increased, reducing plot setbacks and minimising private outdoor spaces as a result.

After independence in 1947, colonial influences were layered over with modernistic Western ideologies of form and material use. Bungalow-style houses that were common in 1950s-60s had no internal outdoor spaces (House D: Figure 9). By late 1970s, backyards had disappeared completely (House E: Figure 9). By 1980s, privatisation and commercialisation of housing schemes resulted in class and income-based gated community developments, catering to middle- and upper middle-class households. In contemporary Lahore, rigid building regulations and strict adherence to street-orientation have resulted in increasingly homogenised house layouts, usually undermining variables like solar-orientation and micro-climate. Typical middle-class houses are now based on a deep-plan configuration with maximised covered area, open-plan layouts and minimal peripheral outdoor spaces (House F: Figure 9).

Spatial layouts in Lahore evolved under changing socio-cultural, economic and political systems. Whilst changes in spatial arrangements were influenced by the larger systems of practice (Watson, 2012), it is critical to understand how these changes in turn influenced the social structures and household practices, and how they ultimately led to resource-intensive configurations in middle-class households in Lahore. These questions are explored through interviews and case-studies in the next section.

4.3. Findings

The analysis reveals three key processes of change in household practice-arrangements which have resulted in increasing household electricity demands in middle-class households in Lahore.

4.3.1. From outdoor to indoor activities

A key process of change in household practice-arrangements has been a shift from outdoor to more indoor activities. In old vernacular houses, outdoor spaces such as central courtyards, projected from the dwelling as extensions of the house, blurring boundaries between inside and out (case-study 1). Domestic life was seen to 'extend into the open' (Pramar, 2005, p. 9). Hafiz, a seventh-generation owner and resident of a 300-year-old haveli in the Walled City recounts how the haveli courtyard was used by his grandparents in early 20th century;

> "The courtyard was the centre of most activity. Women would perform most household chores there, cutting vegetables, preparing food, washing clothes, even bathing the children. In the evenings, the ground would be sprinkled with

> water to allow heat to evaporate… Lifestyle in summers and winters changed quite a lot. In winters, rooms were closed off with doors shut, while in summers, the house was opened up." (Interview H1, case-study 1)

Hafiz's statement points to a key feature of vernacular spatial practices: maintaining a close connection with the outdoors (Figure 10).

Schatzki (2010b) contends that historicity, through circumscription of practice organisation and practical understandings, embraces enjoined, acceptable, and interwoven spatialities; the continuity of practices and/or arrangements underwrites the presence of the past. In Lahore, 'indigenous bungalows' (Khan, 1983, p. 87) resulted in realigning certain colonial arrangements to accommodate cultural practices that persisted through 'practice memory' (Schatzki, 2010b). The backyard (as in case-study 3), now often referred to as "ladies courtyard" (Khan, 1994, p. 94) replaced inner courtyard as centre of activity. The kitchen, instead of being separated from the main house as in bungalows, is now spun around to face the backyard as an integral part of its focal activity. A ladies' sitting room would often be added to maintain values of gendered segregation. The dining room, instead of remaining at front across the drawing room, was now placed behind it for proximity to the kitchen. Ejaz, resident of a Model Town house, built in 1937 (case-study 3), recounts the use of backyard by his grandparents, when the family moved here in 1947:

> "The backyard was generally very large; most family activities took place there, including sleeping at night. The veranda at the back provided a good shaded space to sit, talk and have tea in the evenings" (Interview H3, case-study 3)

Such deviations in house layouts represent a conditionality of pattern to colonial appropriation under persisting traditions and reflect the complex metamorphosis that took place over time.

Under changing building regulations, two major changes in house layout took form; homeowners started enclosing verandas as part of inner rooms. Backyards gradually reduced in size, taking advantage of decreasing property setbacks. These gradual changes occurred in Samina's 1960s house (Figure 11), under her family's changing needs:

> "We didn't need open spaces any longer… Now, we sit in the living room and enjoy the view from inside. We needed the extra space as well. Our refrigerator and freezer are now placed in the living room, which otherwise couldn't be placed outdoors." (Interview H4, case-study 4)

This points to a dominant actor in change from outdoor to indoor practices of comfort, cooking, eating, sleeping and even recreation, that of technological advancements. Hughes (1993) contends

that the electric power system as a 'cultural artefact' (p. 2) has been one of the greatest mediators of social change in the last century. Initially, electricity in Lahore in 1920s was used for ventilating (fans) and lighting, followed by heating. It was not until televisions were introduced that significant changes in household practice-arrangements emerged. In 1964, the first television broadcasting was initiated in Lahore. The initial 3-hour broadcast gradually extended to 8-12 hours. By 1998, 30-40% of Pakistan's population had a television (Table 8).

Figure 10: Conventional cooking practices in open courtyard in Baghbanpura, Lahore, 1949. Photo courtesy: Interviewee H5

Figure 11: Partially covered courtyard housing refrigerator and deep-freezer. Case-study 4

Figure 12: Cooling cabinet used before refrigerators, built 1937. Case-study 3

Figure 13: Typical modern-day living room with large single-glazed window. Case-study 5

However, it seems that televisions had a greater impact on evening recreational practices than on their spatial arrangement, as it continued to be an outdoor activity. As explained by Ghazal and Seerat;

> "When TV first came to our house, we would sit outside to watch it. We had community gatherings where neighbours would gather in the courtyard to

> watch TV. The broadcast lasted for 3-4 hours back then. It became the main pastime in the evenings." (Interview H5, case study 5)
> "Television replaced the elders of the house. Previously, everyone would gather around the elders and listen to their stories and life experiences. Now, they would gather around the TV for 'information' and 'entertainment'." (Interview H8)

Television changed the meaning of family time, interaction with neighbours and entertainment practices. As backyards gradually disappeared due to changing regulations and homeowner requirements, a new indoor space emerged- a designated 'TV-lounge'.

Another factor in spatial re-arrangement of practices from outdoors to indoors, as indicated by interviewees, were changing modes of comfort, specifically the use of air-conditioning for cooling. Faheem recalls;

> "Air-conditioning not only changed our lifestyle but also the design and construction of houses: firstly, houses were now made more compact; also, the central courtyard was now covered up and converted into a living room, a 'TV-lounge' to be more precise." (Interview H2, case-study 2)

In Pakistan, the first wave of air-conditioners came in early 1970s, often brought by family members living abroad. By early 1980s, window-type air-conditioners were locally manufactured. The demand for air-conditioning has continued to increase (see Table 8), becoming standardised in middle-class households. Air-conditioning has transformed from a luxury item to a necessity among the middle class, as a symbol of modernity and success (see also Wilhite, 2008; Sahakian, 2014; Hansen et al., 2016). In all the households interviewed, timespaces of practices were drastically influenced by air-conditioning, which also influenced spatial configurations like sleeping arrangements. Asked when and why his family started sleeping indoors, Dilawar responded;

> "It was in late '70s or early '80s… we got more facilities to maintain comfort indoors. I remember we first bought a desert cooler. Electric fans were used before this, but the cooler made a difference. Once air-conditioning came, it changed everything… when the first ACs were installed, everyone would still sleep together in one room. Now, there is one in every room." (Interview H9)

Whilst prevalence of air-conditioning increased electricity consumption in households, it also had an indirect effect of reducing tolerance of relatively higher outdoor temperatures, further reducing outdoor space use. Hafiz:

> "Actually, we shouldn't need air-conditioning in this room because it has a *roshandaa*n[6]. I should open the doors and vents and be comfortable with just the fan. But because I have just come from an air-conditioned space, I want to go back into an air-conditioned space… If I go somewhere in my car, my air-conditioning will have been switched on before I get into the car." (Interview H1, case-study 1)

Table 8: Electric appliance ownership in Punjab. Source: HIES and MICS Punjab Reports

Appliance	Percentage of households with ownership in Punjab, %					
	HIES*		MICS$			
	1992/93	1996/07	2003/04	2007/08	2011	2014
Air Cooler/Fan	72.7	--	83.3	86.4	92.8	--
Sewing/Knitting Machine	16.9	60.6	52.7	72.7	67.6	--
Television	7.6	39.6	41.6	63.2	63.6	67.6
Washing Machine/Dryer	5.4	30.0	37.8	48.8	50.4	54.8
Refrigerator/Freezer	14.5	20.8	27.9	40.3	46.9	53.1
Radio	8.8	28.5	13.4	40.0	6.4	4.4
Air Conditioner	0.4	2.1	2.8	6.6	6.1	7.7
Personal Computer	0.0	0.1	2.7	8.5	10.5	16.1
Cooking Range/Microwave	0.3	1.6	2.5	6.0	6.7	--

*Household Integrated Economic Survey, Government of Pakistan.
$ Multiple Indicator Cluster Survey, Bureau of Statistics, Punjab.

Electric appliance ownership has gradually increased over time (see Table 8), which is indicative of the changing materiality in performances of various household practices (see e.g. Figure 12). Practices in the past were restricted to following the daily rhythms of the sun but technological advancements in electrification of houses resulted in the temporal blurring of social interactions (Giddens, 1985). Interviewed homeowners view televisions as the main driver for changing rhythms of daily life. As Babar and Samina recall;

> "The day started early in the morning and everybody was asleep by 10pm at night. I once joked with my driver that we used to get up early in the morning, but people don't do that anymore. He replied it's because there was no TV back in those days." (Interview H5)

> "When I was young, we would sleep early and wake up early for *Fajr* (before dawn). We milked the cows and started working in the kitchen. It wasn't like nowadays when people don't go to sleep till 11pm and don't wake up before 11am next morning…Nowadays, people just sit around watching TV all day." (Interview H4)

The research case-studies show that 21st century lifestyles of middle-class homeowners in Lahore are dependent on mechanical means of ventilation and cooling for comfort, especially in contemporary houses (case-study 5) with open plans and large single-glazed windows built without passive design considerations (see Figure 13). Increased indoor practices and inefficiency of houses explain the fact that 47% of total electricity consumed in contemporary houses is attributed to appliances used for space cooling (ADB, 2009). Rigid building regulations prioritise indoor spaces over outdoor, diminishing their functionality and further exacerbating indoor electricity consumption.

4.3.2. From inward to outward oriented design

Eighteenth century European houses were 'regionalised' (Giddens, 1985) into different temporal zones with intense daytime activity in rooms downstairs and sleeping in bedrooms upstairs. This regionalisation was replicated in colonial bungalows. In contrast, traditional Muslim housing, as in the Walled City, was demarcated into distinct zones of gendered spaces and private-public social accessibility through architecture (Petherbridge, 1978).

As shown in case study 1, at the centre would lie the courtyard (private realm)- the female-dominated centre of most household activity (including private activities like bathing, see Figure 14). This core would be surrounded by rooms on various levels (first floor private harems for females) and used for various functions like storage, cooking and sitting (semi-private). At the outer periphery would lie the *bethak* (sitting room) or a second courtyard used for male gatherings which opened onto the street (public). This gendered spatiality was seen in collective spaces specifically designed for gendered practices;

> "In old houses here in the Walled City, there used to be *tharras*[7], where men would sit and chat… It was also very important to have a *rons*[8] in the house. The kitchen would usually be located behind it. Women would sit on that *rons* to comb and oil their hair, make pickles or cut vegetables. They would sit and chat here with the neighbouring women, who would also be doing their house chores. There used to be two here in this house, but they were removed during the renovations. That was very important in the old life style." (Interview H1, case-study 1)

Changing practices of communication together with changing spatial aspirations for the ideal home meant that such practice-arrangements disappeared over time.

Figure 14: Children bathing in courtyard with water bucket, placed on *chowki*, 1949. Photo courtesy: Interviewee H5

Figure 15: Outdoor peripheral spaces in contemporary house. Case-study 5

Colonial-inspired building regulations had a profound effect on privacy required for female practices. Close proximity of narrow outdoor spaces of houses built in 1970s-1980s, with restricted heights of boundary walls (max 2m) conflicted with socio-cultural notions of privacy for females. This resulted in outdoor peripheral voids or non-functional 'negative spaces' (see Figure 15). Baber, a 90-year-old resident of Lahore, talks of his family's experience of observing privacy with changing spatial configuration of the three houses he had lived in; the courtyard house of the Walled City where he was born; a 1960s outward-oriented house in Shadman with high boundary walls and parapets; and a 1980s modern detached house in Garden Town;

> "Privacy has always been a major concern for us. Women in my household don't feel comfortable moving from one part of the house to the other as modern-day layouts don't take privacy into account (talking of Garden Town house). In my previous home in Shadman, this wasn't the case as surrounding houses had no windows facing our house and so women felt more at ease. In the Walled City house, central courtyard was where the elderly women would spend most time…Even though courtyards were open spaces, they respected homeowner's privacy." (Interview H7)

Baber's statement highlights a very important shift in female practices resulting from inward to outward-oriented design; when outdoor spaces no longer provided the necessary privacy for female practices, most household chores were essentially shifted indoors as household practices related to cooking, cleaning and laundering are undertaken by females. Consequently, additional electricity for ventilation, cooling and lighting was needed to make indoor spaces functional for performing these practices.

From 1990 onwards, a further increase in electricity consumption can be witnessed, caused by the diminishing of privacy in the design of indoor spaces. For instance, Western-inspired large windows are kept covered due to privacy concerns;

> "I want to have my privacy when I am in my bedroom. I like that the curtains remain drawn always… I don't feel comfortable if neighbours and house staff can see inside" (Interview H5, case-study 5)

Open-plan living and kitchen space is another Western-inspired design feature that results in increased use of air-conditioning to make these large spaces comfortable. Contemporary house spaces and their conflicts with routine practices and cultural norms in middle-class households in Lahore have been discussed in detail in our previous research (see Khalid and Sunikka-Blank, 2017). Such conflicts, for example between open-plan spaces and social norms of privacy and segregation, ultimately result in compromising more sustainable variants of practice-arrangements; for instance, more outdoor space use instead of indoor; more collective spaces instead of individual, passive comfort instead of mechanical, and maximising daylight instead of artificial lighting. This ultimately leads to increased electricity consumption in households.

4.3.3. Spatial dispersion of practices

Another key change in domestic practice-arrangements has been the specification of spaces for particular use, resulting in a wider spatial dispersion of practices. In traditional Muslim households, going as far back as 18th century, interior spaces were designed to be 'functionally polyvalent' (Petherbridge, 1978, p. 199). Rooms were used interchangeably for eating, sleeping, recreation and household chores. This informal allocation of space-use was also conducive to joint family structures (Pramar, 2005) and ensured maximum utilisation of available space. In Lahore, the central courtyard (case-study 1) played a significant role in multifunctionality as the heart of most household activity. Baber, aged 90, emphasises on the spatial compactness of practices as an inherent characteristic of his childhood *haveli* life;

> "Courtyard was a major element of our social life as a family unit…There were six rooms shared by my father and his brothers living together with their families (joint family system). There was no separate dining room. For meals, we would all sit in the kitchen next to the courtyard where our mother cooked. In winters we ate in the kitchen and in summers we ate outside in the courtyard." (Interview H7)

Light furnishings, such as *charpai*[15] or *chowki*[16] (see Figure 10 and 14) that could be moved easily[17] endorsed flexibility in the use of spaces. Colonialism had sown the seeds of 'refinement and good taste' (Glover, 2008, p. 166) in furnishings which gradually took root. For example, c*harpai* were gradually replaced with single wooden bedframes. Supplementing this were the emergent changes in sleeping practices. Till late 1970s, common practice was to sleep outdoors. With improved mechanical ventilation and heavy bedding, sleeping arrangements changed. Dilawar;

> "There would be a number of rooms on each floor, used as needed… Back then, it wasn't customary to have beds. We had *charpai* which we would take to the rooftop in summers. In winters, we slept indoors. Things changed gradually. Initially, single beds became available. Those who could afford them started buying beds for everyone in the house. I think it was around early '70s that double beds came into fashion." (Interview H9)

Whereas most household practices like cooking, eating, laundering, bathing, washing, entertainment and sleeping were previously performed within the single space of the courtyard, practices gradually started to disperse in the indigenous bungalows. Introduction of dining rooms meant that cooking and eating were separated into two distinct spaces. Bathing and washing were provided a distinct space in the form of bathrooms, which gradually separated into individualised en-suite bathrooms with every bedroom in houses built in 1970s onwards. By 1980s, laundering was separated from cooking into a distinct laundering area. Entertainment practices became more extensive and widespread, both temporally and spatially; Mrs. Ejaz;

> "There used to be a single TV for the whole household. Now, Ejaz's parents have their own TV in their bedroom, where they prefer to watch it in evening, while Ejaz and I are watching (TV) in our sitting-room. The children watch their own programmes, and so are often in the other living room. Everyone has their own preference for TV programmes". (Interview H3, in case-study 3)

Changing middle-class lifestyles in Pakistan in the 21st century show that contemporary household practices entail larger bedrooms, bathrooms and wardrobes and therefore higher electricity consumption. The modern-day house as a symbol of social status means that redundant spaces are often deemed necessary, beyond functionality and practice performance, such as having two separate

[15] Charpai, charpaya charpoy or manji (in Urdu, Saraiki, Punjabi; char "four" + paya "footed") is a traditional woven bed used in the Indian subcontinent. The net is made of cotton, natural fibres and date leaves.

[16] *Chowki, chauki or chawki* is a low wooden seat or stool.

[17] Walker (1894), representing a European's perspective on city life in Lahore in 1894, comments on this lack of furniture: 'the furniture in most of the city houses is of the barest description. A piece of carpet… a few wooden boards, some reed stools about half a foot high, woven with cotton thread, and a number of ordinary cots complete the furniture of an ordinary trader's house'. (Walker, 1894, p. 63)

kitchens (a main kitchen with latest fittings more for show and a smaller kitchen where actual cooking and dishwashing are performed; see Figure 17-18). Similar escalating electricity consumption trends are also evident in Western housing, where house sizes and amenities have continued to increase over the last 30 years, while average household sizes have decreased (Calwell, 2010).

Figure 16: Open kitchen in haveli courtyard. Case-study 1

Figure 17: Main kitchen, built 2015

Figure 18: Supplementary kitchen adjacent to main kitchen, built 2015

However, spatial dispersion of practices for further individualised use is not just dependent on changes in material configurations and technologies. It is also the result of a changing culture from collective to more individualised practice performances. According to the interviewees, simpler more collective practices were performed in the past, when notions of individualised spaces did not exist. According to Samina and Dilawar;

> "Back then it wasn't the norm to have a lot of rooms…to have separate bedrooms for everyone. Everyone used to sleep and live together… This is quite a recent trend. Now, everyone demands a separate bedroom for so-called privacy." (Interview H4)

> **"**Back then if people had one or two rooms in the house, the number of occupants was usually high- around 10-12. Generally, everyone would sleep together in the same room. People were much simpler as well… Now, everyone demands their own mobiles, laptops, even their own ACs… if there is a guest coming over and someone in the house has to share a room, they are distraught! Children cannot bear any kind of interference anymore." (Interview H9)

However, as Khan (1994) highlights, the process of appropriation of colonial and later Western ideologies (spatial or otherwise) was not linear and uncomplicated. In contemporary houses in Lahore (case-study 5), spatially dispersed domestic spaces conflict with joint family multi-generational occupation of houses. There are very few 'nuclear families' in the Western sense. Bound by historicities of joint family practices and cultural obligations, households are inclined to allocate designated spaces for grandparents, in-laws and extended family. Contingency planning for future needs of children as well as religious and social obligations of taking care of elderly parents are socio-cultural underpinnings of society. These, seen through the lens of historicity, have persisted through material disruptions brought about by colonisation and Westernisation, and still govern house planning. Furthered by western influences of capitalist consumerism, these have resulted in a complex and often contradictory blend of values and aesthetics, forms and functions of contemporary practice-arrangements[18]. Most homeowners navigate this complex interplay by compromising and negotiating between conflicting practices, as exemplified by Ghazal's decision for an open-plan living room and no formal drawing room in her house;

[18] There are several detailed readings of post-colonial influences on spaces and practices of Lahore that provide depth to this issue. In the analysis of architectural spaces, Khan (1983, 1994) and Mumtaz (1985, 1999) look at the conflicting ideologies of tradition and colonialism, and their metamorphosis into modified, controlled or moderated forms under changing socio-cultural values in Lahore. Through his empirical study of evolution of a local housing community of 1960s, Khan identifies the multiplicity of relations that connect architectural past to the present, revealing the social reality of a society still struggling to free itself from the socio-cultural and economic aftermath of colonialism. Mumtaz (1999), who is a strong contester of modernity in architecture in Lahore, suggests that for the Pakistani society, the process of transformation under industrialisation and westernisation has not been thorough. While modernity might be more visible in form, below the surface, there still survive traditional values, concepts, social relations and patterns of behaviour. Glover's (2008) study of 'making Lahore modern' under colonialism is unique in that it presents a socio-material and cultural perspective of changing domestic life, both in terms of architectural spaces and cultural practices. He contends that urban change in colonial Lahore was not a monolithic process; pre-existing peculiarities of history and culture, of climate and resources all play a role in Lahore's subsequent development. Using 'object lessons', Glover looks at Lahore as a 'hybrid city', where both the vernacular and the colonial underwent modernity in their own ways, incorporating a variety of practices, building forms and cultural values, resulting in collaborations and contestations

> "I feel its absence (drawing room), when a male acquaintance is visiting. I am imprisoned in my room then (because of lack of privacy of open-plan living room). If the weather permits, we seat guests outside in the lawn or veranda. Otherwise…it becomes difficult for me. I give instructions to my kitchen staff on the phone then. We have thought of different solutions for this… once my son proposed to convert this (master bed) into a drawing room, and we move to the bedroom on the back, but that was out of the question, as I would lose my view of the lawn." (Interview H5, case-study 5)

Spatial dispersion of practices is not confined to household level, but also evident in the urban fabric and the shift from inclusive to exclusive zoning (section 4.2.3). While this has increased travelling distances for routine practices like shopping, getting groceries and going to work, it has also shaped how household practices are performed. The example of the haveli in case-study 1, provides example of this; its occupants own a single refrigerator and no deep-freezer. The kitchen, contrary to other case-study houses, is still partly located in the open courtyard (see Figure 16), where cooking and dish-washing take place. *Haveli* homeowners are also able to rely on easily accessible outsourcing laundering facilities. This is a characteristic of living in the Walled City and the type of inclusive zoning it offers;

> "The haveli is in the centre of the market place. Whenever we need something, rather than stocking up groceries, everything is readily available from the market nearby. The market-place culture is like this- they remain open till 4am. So, anything we need is readily available even very late at night. Look, right opposite our house, there is a bakery, a *chai wala* (tea server), *tandoor* (bread oven), even an ATM, a tailor, a watch maker right at our doorstep." (Interview H1, case-study 1)

This indicates that changes in cooking and laundering practices and resulting electricity consumption is not just dependent on available technology in terms of appliances, but also on cultural practices shaped by local urban fabric. Compared to modern, exclusively planned residential housing, inclusive mixed-use zoning, which offsets social dispersion of practices, ensures homeowners do not have to travel far for daily needs. Such easily accessible community-based practices result in very different household electricity profiles compared to contemporary conventional houses. It also implies that when material arrangements of houses are studied to understand how they influence practices, the urban fabric and scale should also be considered.

4.4. Conclusions

This study shows that a historical analysis of coevolution of household practices and spatial layouts of middle-class houses in Pakistan can improve our understanding of how and why domestic electricity consumption continues to increase in the Global South, despite improvements in appliances and building fabric. Adopting a practice theoretical framework and Schatzki's (2010a, 2010b) concepts of historicity and prefiguration helped identify nexuses of 'practice-arrangement bundles' in urban housing that have emerged, persisted and transformed over time, resulting in unsustainable electricity consumption in middle-class households.

Based on archival documents, floor plan analysis, case-studies, historical narratives and expert interviews, three key themes were identified; shift from outdoor to indoor activities, from inward to outward oriented design, and spatial dispersion of practices. Culturally ill-suited and diminishing outdoor spaces gradually resulted in practices moving from outdoors to indoors. Consequently, indoor spaces were adapted to accommodate these practices, leading to increased air-conditioning (in Punjab, from 1992 to 2014, AC unit ownership increased by 19 times (Table 8)). While the impact of technology (air-conditioning and television in particular) has been important, assigning it complete agentive power is misleading. Such a myopic view fails to capture what Guy and Shove (2000) cite as the 'social negotiation of need' or 'the structuring of choice' in the 'creation of demand' (p. 70). This paper shows that current practice-arrangements in middle-class households in Lahore have emerged through a longitudinal process of coevolution, where both social and material structures have mutually shaped the edifice of middle-class housing and subsequent energy demands. Where technologies have encouraged more indoor-based activities, blind following of Westernised spatial configurations and housing communities without any mixed use reinforce such practice-arrangements that necessitate higher electricity demands.

Changes in spatial layout are a result of complex transformation including colonisation, Westernisation and consumerism but also on-going traditional values and norms such as joint family structures and gender segregation. Further, each housing unit exists in a specific local context and site, under certain regulations and byelaws which have a profound effect on household practices. For example, in the last 30 years, setbacks at the rear of houses have decreased by up to 50%, further diminishing the role of backyard as centre of household practices.

The analysis presented here shows that post-independence practice-arrangement bundles of middle-class houses in Lahore were entrapped by historicities of colonial imaginations. This colonial influence further instigated a Westernised approach to spatial constructions, such as more individualised practices in indoor spaces instead of collective practices in multifunctional outdoor spaces. This Western influence that is climatically but also culturally ill-suited can be seen in contemporary houses. Historicity also revealed the persistence of certain cultural images of privacy,

gender segregation and joint family systems. These, when juxtaposed with modern spatial configurations, give rise to conflicts in practices where, for example, open-plan houses do not provide adequate privacy indoors or link to outdoors.

This conceptualisation provides evidence of context dependent nature of practices. It also reifies how historicity and prefiguration can prove useful in understanding the complex negotiations between the sometimes collaborative (e.g. replacement of vernacular courtyard with backyard in indigenous *bungalow* as centre of activity) and sometimes conflicting values and requirements (e.g. contemporary open plan, largely glazed spaces that do not offer privacy and localised comfort). Further, understanding longitudinal dynamics of practice-arrangements can help recognise and therefore prevent normalisation of standards for the 'perfect' home that gradually become embedded and engrained in social practices and institutional systems. Contemporary standards in middle-class household practice-arrangements are likely to prefigure higher demands for electricity through increased consumption and specification of spaces, unquestioned reliance on electricity and neglected use of outdoor space.

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References

ADB, 2009. Pakistan: Sustainable Energy Efficiency Development Program (Technical Assistance Consultant's Final Report. Prepared by Hagler Bailly Pakistan and Econoler International No. ADB TA 7060-PAK). Asian Development Bank (ADB), Islamabad.

Alahdad, Z., 2012. Pakistan's energy sector: From crises to crises- breaking the chain. Pakistan Institute of Development Economics, Islamabad.

Atkinson, P., Coffey, A., 2003. Revisiting the relationship between participant observation and interviewing, in: Holstein, J.A., Gubrium, J.F. (Eds.), Postmodern Interviewing. SAGE Publications, Inc., London, pp. 108–122. https://doi.org/10.4135/9781412984492

Bourdieu, P., 1996. Physical space, social space and habitus. Vilhelm Aubert Meml. Lect. Rep. 10.

Bourdieu, P., 1981. Men and machines, in: Cetina, K.K., Cicourel, A.V. (Eds.), Advances in Social Theory and Methodology: Toward an Integration of Micro- and Macro-Sociologies. Routledge & Kegan Paul, Boston, pp. 304–317.

Bourdieu, P., 1970. The Berber house or the world reversed. Inf. Int. Soc. Sci. Counc. 9, 151–170.

Browne, A.L., 2016. Histories, Trajectories and Patterns of Cleanliness, Energy and Water Consumption: Reflections on China. DEMAND Centre Conference Lancaster.

Calwell, C., 2010. Is efficient sufficient? The case for shifting our emphasis in energy specifications to progressive efficiency and sufficiency (Report for the European Council of Energy Efficient Economy (ECEEE)). ECEEE, Stockholm, Sweden.

Edwards, B., Sibly, M., Hakmi, M., Land, P. (Eds.), 2006. Courtyard housing: past, present, and future. Taylor & Francis, Abingdon; New York.

EIA, 2016. International Energy Outlook 2016. U.S. Energy Information Administration (EIA), Washington, D.C.

Flyvbjerg, B., 2006. Five Misunderstandings About Case-Study Research. Qual. Inq. 12, 219–245. https://doi.org/10.1177/1077800405284363

Forsey, M.G., 2010. Ethnography as participant listening. Ethnography 11, 558–572. https://doi.org/10.1177/1466138110372587

Ghani, J.A., 2014. The emerging middle class in Pakistan: how it consumes, earns, and saves, in: International Conference on Marketing. Presented at the IBAICM 2014, Institute of Business Administration (IBA) Karachi, Karachi.

Giddens, A., 1993. Preface, in: Society Action and Space: An Alternative Human Geography. Routledge, London, pp. xii–xv.

Giddens, A., 1985. Time, Space and Regionalisation, in: Social Relations and Spatial Structures, Critical Human Geography. Palgrave, London, pp. 265–295. https://doi.org/10.1007/978-1-349-27935-7_12

Giddens, A., 1984. Space, Time, and Politics in Social Theory: An Interview with Anthony Giddens. Environ. Plan. Soc. Space 2, 123–132. https://doi.org/10.1068/d020123

Gieryn, T.F., 2002. What buildings do. Theory Soc. 31, 35–74.

Glover, W.J., 2008. Making Lahore Modern: Constructing and Imagining a Colonial City. University of Minnesota Press, Minneapolis.

Gram-Hanssen, K., 2014. New needs for better understanding of household's energy consumption – behaviour, lifestyle or practices? Archit. Eng. Des. Manag. 10, 91–107. https://doi.org/10.1080/17452007.2013.837251

Gram-Hanssen, K., 2009. Standby Consumption in Households Analyzed With a Practice Theory Approach. J. Ind. Ecol. 14, 150–165. https://doi.org/10.1111/j.1530-9290.2009.00194.x

Gram-Hanssen, K., 2008. Consuming technologies – developing routines. J. Clean. Prod. 16, 1181–1189. https://doi.org/10.1016/j.jclepro.2007.08.006

Guy, S., Shove, E., 2000. A sociology of energy, buildings, and the environment: constructing knowledge, designing practice. Routledge, London; New York.

Halkier, B., 2017. Questioning the 'gold standard' thinking in qualitative methods from a practice theoretical perspective: Towards methodological multiplicity, in: Jonas, M., Littig, B., Wroblewski, A. (Eds.), Methodological Reflections on Practice Oriented Theories. Springer International Publishing, Cham, Switzerland, pp. 193–204.

Halkier, B., Jensen, I., 2011a. Doing 'healthier' food in everyday life? A qualitative study of how Pakistani Danes handle nutritional communication. Crit. Public Health 21, 471–483. https://doi.org/10.1080/09581596.2011.594873

Halkier, B., Jensen, I., 2011b. Methodological challenges in using practice theory in consumption research. Examples from a study on handling nutritional contestations of food consumption. J. Consum. Cult. 11, 101–123. https://doi.org/10.1177/1469540510391365

Halkier, B., Katz-Gerro, T., Martens, L., 2011. Applying practice theory to the study of consumption: Theoretical and methodological considerations. J. Consum. Cult. 11, 3–13. https://doi.org/10.1177/1469540510391765

Hand, M., Shove, E., Southerton, D., 2007. Home Extensions in the United Kingdom: Space, Time, and Practice. Environ. Plan. Soc. Space 25, 668–681. https://doi.org/10.1068/d413t

Hand, M., Shove, E., Southerton, D., 2005. Explaining showering: a discussion of the material, conventional, and temporal dimensions of practice. Sociol. Res. Online 10. https://doi.org/10.5153/sro.1100

Hansen, A., Nielsen, K.B., Wilhite, H., 2016. Staying Cool, Looking Good, Moving Around: Consumption, Sustainability and the 'Rise of the South.' Forum Dev. Stud. 43, 5–25. https://doi.org/10.1080/08039410.2015.1134640

Hughes, T.P., 1993. Networks of Power: Electrification in Western Society, 1880-1930. JHU Press.

Judson, E.P., Maller, C., 2014. Housing renovations and energy efficiency: insights from homeowners' practices. Build. Res. Inf. 42, 501–511. https://doi.org/10.1080/09613218.2014.894808

Khalid, R., Sunikka-Blank, M., 2017. Homely social practices, uncanny electricity demands: Class, culture and material dynamics in Pakistan. Energy Res. Soc. Sci. 34, 122–131. https://doi.org/10.1016/j.erss.2017.06.038

Khan, M., 1994. Cultural Transfers: The Repossession of Architectural Form. Environ. Des. J. Islam. Environ. Des. Res. Cent. 1-2 84–103.

Khan, M.A., 1983. "Informal" architecture: an examination of some adaptive processes in architectural traditions (MSc thesis). Massachusetts Institute of Technology.

King, A.D., 1984. The Bungalow: The Production of a Global Culture. Routledge & Kegan Paul, London.

Kuijer, L., Watson, M., 2017. 'That's when we started using the living room': Lessons from a local history of domestic heating in the United Kingdom. Energy Res. Soc. Sci. 28, 77–85. https://doi.org/10.1016/j.erss.2017.04.010

LIT, 1941. Annual Administration Report of Lahore Improvement Trust 1940-41 (Annual Administrative Report). Government of Punjab, Pakistan, Lahore.

Mumtaz, K.K., 1999. Modernity and Tradition: Contemporary Architecture in Pakistan. Oxford University Press.

Mumtaz, K.K., 1985. A case for indigenous development, in: Powell, R. (Ed.), Regionalism in Architecture, Exploring Architecture in Islamic Cultures 2. Published for the Aga Khan Award for Architecture, 1985 by Concept Media, Singapore, pp. 55–57.

National Housing Policy Pakistan, 2001. National Housing Policy. Ministry of Housing & Works, Government of Pakistan, Islamabad.

Petherbridge, G.T., 1978. Vernacular Architecture: The House and Society, in: Michell, G. (Ed.), Architecture of the Islamic World: Its History and Social Meaning. Thames and Hudson Ltd, London, pp. 176–208.

Pramar, V.S., 2005. A Social History of Indian Architecture. Oxford University Press, New Delhi.

Rinkinen, J., Jalas, M., Shove, E., 2015. Object Relations in Accounts of Everyday Life. Sociology 49, 870–885. https://doi.org/10.1177/0038038515577910

Ropke, I., Gram-Hanssen, K., Jensen, J.O., 2007. Households' ICT use in an energy perspective, in: The Good, the Bad and the Unexpected: The User and the Future of Information and Communication Technologies. Presented at the COST Action 298, Russian Federation, Moscow, pp. 595–611.

Sahakian, M., 2014. Keeping Cool in Southeast Asia: Energy Consumption and Urban Air-Conditioning. Palgrave Macmillan UK.

Schatzki, T., 2006. On Studying the Past Scientifically. Inquiry 49, 380–399. https://doi.org/10.1080/00201740600831505

Schatzki, T.R., 2013. The edge of change: on the emergence, persistence and dissolution of practices, in: Shove, E., Spurling, N. (Eds.), Sustainable Practices: Social Theory and Climate Change. Routledge, Oxfordshire, pp. 31–46.

Schatzki, T.R., 2011. Where the action is (on large social phenomena such as sociotechnical regimes). Sustain. Pract. Res. Group Work. Pap. 1.

Schatzki, T.R., 2010a. Materiality and Social Life. Nat. Cult. 5, 123–149. https://doi.org/10.3167/nc.2010.050202

Schatzki, T.R., 2010b. The timespace of human activity: on performance, society, and history as indeterminate teleological events, Toposophia. Lexington Books, Lanham, Md.

Shorto, S., 2007. A tomb of one's own: The Governor's house, Lahore, in: Scriver, P., Prakash, V. (Eds.), Colonial Modernities: Building, Dwelling and Architecture in British India and Ceylon. Routledge, Abingdon, pp. 151–167.

Shove, E., 2016. Matters of practice, in: The Nexus of Practices: Connections, Constellations, Practitioners. Taylor & Francis, Abingdon; New York, pp. 155–168.

Shove, E., 2010. Beyond the ABC: Climate Change Policy and Theories of Social Change. Environ. Plan. A 42, 1273–1285. https://doi.org/10.1068/a42282

Shove, E., Walker, G., 2014. What Is Energy For? Social Practice and Energy Demand. Theory Cult. Soc. 31, 41–58. https://doi.org/10.1177/0263276414536746

Smits, M., 2011. Progressive contextualisation of energy practices and trajectories: A case study in Thailand. Rural Soc. 20, 280–293. https://doi.org/10.5172/rsj.20.3.280

Strengers, Y., 2010. Conceptualising everyday practices: composition, reproduction and change. Carbon Neutral Communities Work. Pap.

Thompson, P., 1972. Problems of method in oral history. Oral Hist. 1, 1–47.

Tiwari, P., Rao, J., 2016. Housing markets and housing policies in India, in: ADB Institute, ADBI Working Paper Series.

UNDP, 2013. The rise of the South: Human Progress in a Diverse World (Human Development Report). United Nations Development Programme, New York.

Walker, G., Shove, E., Brown, S., 2014. How does air conditioning become 'needed'? A case study of routes, rationales and dynamics. Energy Res. Soc. Sci. 4, 1–9. https://doi.org/10.1016/j.erss.2014.08.002

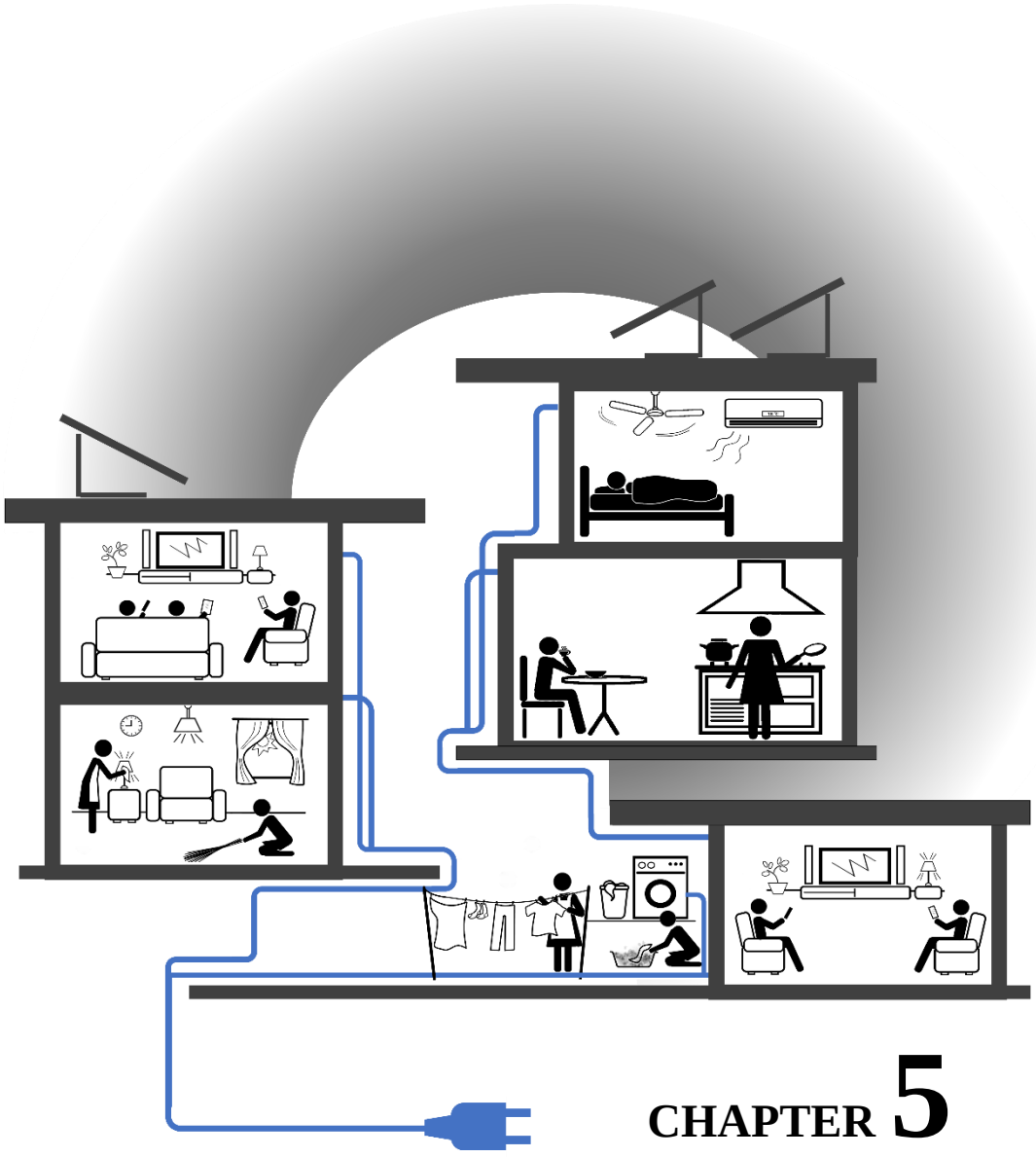
Walker, G.C., 1894. Gazetteer of the Lahore District, 1893-94, Lahore District. Lahore Civil and Military Gazette Press, Lahore.

Warde, A., 2005. Consumption and theories of practice. J. Consum. Cult. 5, 131–153.

Watson, M., 2012. How theories of practice can inform transition to a decarbonised transport system. J. Transp. Geogr. 24, 488–496. https://doi.org/10.1016/j.jtrangeo.2012.04.002

Wilhite, H., 2008. Consumption and the transformation of everyday life: a view from South India. Palgrave Macmillan, Hampshire.

World Bank, 2017. Pakistan - Housing Finance Project. World Bank Group, Washington, D.C.



CHAPTER 5

5. Cross-cultural analysis of household practices

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Abstract

Future smart infrastructure development, in both developing and developed countries, is hinged on demand management and response strategies with consumers actively involved in time-shifting electricity consumption for improved efficiency. This paper presents a qualitative, interview-based, comparative study of how homeowners adapt their practices to the changing systems of electricity provision in two countries, Pakistan and Denmark. It reveals that household practices like laundering are flexible, highly contextualised and embedded in the wider socio-material and cultural context.

In Denmark, time-shifting of laundering in households with photovoltaics is done voluntarily and closely interwoven with the temporal rhythms of the common dual-income household, as well as the natural cycles of the sun and weather, and is in most cases based on some degree of automation. In Pakistan, blackout schedules dictate time-shifting of most practices. Large family sizes and nuanced clothing make laundering more complex, socially-bound and time-consuming; however, joint family systems, provision of house-staff and outsourcing make it more time-flexible and less dependent on

automation and electricity-use. Using theories on temporalities of practices in a cross-cultural analysis highlights the significance of local socio-material and cultural context in the performance, bundling and synchronisation of practices. While practice theories prove useful in cross-cultural comparison of temporalities of household practices and demand, further theory development is needed to conceptualise practices as shared or socially differentiated entities in varying cultural contexts. This has implications for demand management policies proposed in smart-grid transitions as well as in the possible cross-cultural transfer of smart technology and demand response strategies.

Key words: Smart infrastructure; developing countries; developed countries; time-shifting; electricity consumption; household practices

5.1. Introduction

Demand Side Management is at the core of climate change mitigation and realisation of future energy targets. The globally converging and growing energy demand, significant shift towards intermittent and distributed renewable generation and the imminent integration of 'smart' systems have highlighted the need for demand management and effective demand response (Torriti et al., 2010; Walker, 2014).

Massive investments in Advanced Metering Infrastructures (AMI) as part of the future smart grid have become evident globally in the last decennium (Darby, 2010; Buchanan et al., 2015). Such infrastructure development plans, in both developed and developing countries, are based on the changing perception of energy supply and demand, with reliance on end-users as more active participants in demand management through time-shifting of their electricity loads or even as 'prosumers' (Ellsworth-Krebs and Reid, 2016), that is households that produce as well as consume energy. Such infrastructure developments are part of future policies in both Denmark, a country which is at the forefront of 'smart' projects and Pakistan, a developing country that faces increasing gaps between its energy supply and demand.

However, the 'smart ontology' mainly constitutes demand policies that mediate transitions through rational individual choice based on information exchange and technological upgrades (Strengers, 2013). These policies fail to capture the user's flexibility and limitations in making such transitions. Hence, a socio-technical approach in transitioning to a 'smart' energy provision system necessitates the consideration of the energy system not only as defining and shaping everyday routines and practices of households, but also in turn being shaped by these very practices (Shove et al., 2009; Shove and Walker, 2014).

Whilst understanding the flexibility of energy use in relation to household practices has formed the basis of empirical work in single case-studies (Strengers, 2012, 2013; Powells et al., 2014; Higginson et al., 2014; Nicholls and Strengers, 2015; Friis and Christensen, 2016), comparative studies that

analyse cross-cultural diversities in energy consumption and everyday practices like those of eating (Durand-Daubin and Anderson, 2018), refrigerating/freezing (Rinkinen et al., 2017), reading (Southerton et al., 2012), comfort (Hansen et al., 2016; Heidenstrøm et al., 2013), energy retrofitting (Bartiaux et al., 2014), etc are limited. Further still, comparative studies between countries in the West and East or in the Global North and South are almost non-existent. Among the few exceptions is Wilhite et al.'s (1996) cross-cultural study of Japan and Norway which juxtaposed similar material culture profiles in differing cultural contexts and exemplified how certain household practices are more firmly bound by local traditions and conventions than others. Cultural diversity in bathing practices in the Netherlands, India and Japan has been the focus of Matsuhashi et al. (2009). Through the comparison of significantly different cultural practices, they highlight how exploring cultural diversity and variety in practices can inspire less resource-intensive solutions.

In the globally recognised aspirations for shift towards the smart grid, one key challenge is that while the same technology can be employed in smart infrastructure worldwide, its processing and operation cannot be assumed to be similar due to the 'social and cultural properties of infrastructures-in-use' (Shove et al., 2015, p. 279). Infrastructure as materiality co-constitutes specific practice formations in specific socio-material contexts. Based on historically contingent norms and standards, it is also generally designed to be relatively resilient (often developed for long-term) and so prefigures socio-material arrangements and temporalities of demand and shapes patterns of future energy transitions (Shove et al., 2015; Spurling, 2018) A cross-cultural analysis can not only provide context-sensitive insights into the socio-culturally embedded nature of technology and infrastructure, but also help determine users' flexibility and consequently form policies for such smart developments to effectively produce sustainable transitions.

Research presented in this paper thus focuses on a comparative study of how homeowners adapt the temporalities of their practices to the changing systems of electricity provision in two countries, Pakistan and Denmark. Denmark's policy goal for shifting to 100% renewable resources by 2050 includes, among other things, establishing a smart grid, including rollout of smart meters that facilitate remote automated metering, and demand management policies for high percentages of intermittent wind power (Danish Government, 2011, 2013). In Pakistan, contractual agreements for 'smart' meter rollout throughout the country are currently underway as a means to reduce fraud and distribution losses and improve accuracy in billing (Aslam et al., 2015). Net metering has recently been approved to encourage private investment in renewable microgeneration[19]. Currently, the common form of demand management undertaken in Pakistan is electricity load-shedding, where power is shut down intermittently for 4-8 hours daily in urban areas.

[19] See Irfan et al. (2017) for detailed review of opportunities and challenges of smart grid development and IRENA (2018) for renewable energy assessment of Pakistan.

Although these two countries have very different economic, climatic, geographic, socio-cultural and housing contexts, both have policy objectives of transitioning to some form of smart grid with promotion of microgeneration integration, which makes the comparison interesting. Comparing similar household practices in such diverse contexts provide greater insights into improved demand management and response strategies in each of the two countries, as well as more generally.

This paper aims to present an in-depth comparative analysis of laundry practices in middle-class households in Pakistan and Denmark to explore the relationship between practice temporalities, culture and consumption. It responds to Anderson's (2016) call for a comparative analysis of laundry practices across different climates and cultures for demand flexibility and builds on Mylan and Southerton's (2017) arguments of domestic laundering as a good example of the social ordering of practices at micro-macro levels. As a resource intensive practice (Chaudhry, 2010; Gram-Hanssen, 2014b) that is considered to be flexible (Higginson et al., 2014; Powells et al., 2014), laundering also provides a good example for understanding time-shifting for improved demand response in a smart-grid transition.

Thus, through a cross-cultural analysis, the study seeks to examine the extent to which temporalities of practices are defined by the given socio-material and cultural context and what this means for smart infrastructure development. Based on the empirical work, the study also aims to determine the usefulness of theories of practices and temporalities in analysing time-shifting of practices in the context of different countries. It further examines how a practice-based approach can inform the possible transfer of smart infrastructure technology and demand response strategies from one culture to another. This discussion will then help formulate policy implications.

The theoretical framework that forms the basis of our comparative analysis is presented in Section 5.2, followed by the method adopted in section 5.3. Findings of the analysis are presented in section 5.4 with discussion in section 5.5 and conclusions in section 5.6.

5.2. Dynamics of household practices and energy demand

The sociology of consumption took a 'practice turn' (Schatzki et al., 2001) in contemporary social theory, shifting focus from the 'symbolic' to the 'routine' and 'habitual' character of consumption (e.g. Gronow and Warde, 2001). Practices came to be understood as the 'temporally unfolding and spatially dispersed nexus of doings and sayings' (Schatzki, 1996, p. 89) and that consumption takes place as 'a moment in almost every practice' (Warde, 2005, p. 137). When practices take centre-stage, societal transition and change in consumption can be understood as the evolution of practices and their inherent links that are taking place within society (Schatzki et al., 2001; Warde, 2005; Shove et al., 2012). The various interlinked and interconnected 'bundles' of loosely knit practices or 'complexes' of more tightly integrated and interdependent practices (Shove et al., 2012) compete for

both time and resources. In this sense, the temporal rhythms of practices – the frequency, duration, sequencing and scheduling of daily routines – shape the temporal patterns of energy use in the household and on the aggregated, societal level (Shove et al., 2009).

According to Southerton (2012, 2009), temporalities of practices are highly influenced by culturally derived dispositions; that is, 'shared orientations towards the performance of practices' (Southerton, 2012, p. 341). The term culture may in some understandings of theories of practices be in conflict with a practice-theoretical framework; however, in the present study, culture does not represent 'symbolic display, communication and presentation of self' (Warde, 2014, p. 287)[20]. Rather, it denotes the specific temporally, historically and regionally contingent socio-material settings shared by practice performances in a given context. Practice performances are shaped by tacit knowledge and embodied skills as well as sequences of activities guided by institutional and material scripts (Southerton, 2012) and cultural constructs (Jack, 2013). According to Warde (2013), rules and procedures configure cultural understandings of practices, which are produced and consolidated in cultural contexts. In analysing the global dissemination of social practices in different countries, cultures and communities, Shove and Pantzar (2005) contend that practices and associated cultures of consumption are always 'homegrown' (p. 62). Even though the transfer of certain technologies (or even knowledge and/or engagements) in the globalised world of today is inevitable, the emergence and evolution of practices is necessarily localised, in which cultural history plays an important part (Shove and Pantzar, 2005).

Mylan and Southerton (2017) highlight a number of social mechanisms that order the performance of laundry practices at the personal, household and societal level, including social relations within the households (e.g. gender divisions of domestic labour) and cultural conventions that act as cultural ideals for laundering (e.g. softness and smell of freshly laundered clothes, convenience, etc.). Materiality is another social mechanism identified by Mylan and Southerton, but that has been elaborated further and in more detail by Spurling (2018), who focuses on the material dependencies of temporalities; accordingly, technologies and infrastructures are partially responsible for setting the temporal patterns of energy consumption by co-constituting the sequence, duration, frequency, and temporal location of various practices. Combining these two approaches, this paper focuses on understanding the role of socio-material settings in time-shifting of household practices.

Southerton (2003) provides insight into the temporality of everyday life, and how this orchestrates the timing of daily practices, with the concepts of 'hot spots' and 'cold spots'. These are essential components for time management of practice performances within allocated personal and collective rhythms that configure practices, such as institutional and seasonal timings (Southerton, 2012). 'Hot spots' are the predictable periods of the day densely packed with activities that typically precede

[20] See Warde (2014) for detailed description of cultural analysis and its comparison with practice theory.

institutionally timed events, such as work, school or meal times. Such hot spots lie between loosely formed time periods, referred to as 'cold spots', that are perceived as 'quality time' and 'bonding time', filled with 'meaningful' (p. 19) social activities.

Walker (2014) contends that the rhythms of routine, energy-consuming activities, when combined and scaled up, form the resonant load profiles of grid infrastructures. Closely interrelated with these rhythms is the concept of synchronisation, which relates to 'the relationships between rhythms' (Walker, 2014, p. 52) of practices. Walker identifies two types of synchronisations: social synchronisation formed by the socially shared rhythms of practices like cooking and eating. Such institutional and societal patterns of synchronisation become significant during peak demands. Walker notes that socially shared rhythms may have stronger or weaker bonds and vary in character between societies and cultures- a point of significance in the present comparative analysis. The second type of synchronisation is natural-social synchronisation formed by the linking of natural rhythms of especially the solar daylight hours to the social rhythms of practices e.g. in sleeping.

Walker (2014) highlights the emergence of a second form of natural-social synchronisation brought about by the increasing focus on intermittent renewable energy into the energy supply mix. The changing systems of electricity provision thus provide an opportunity for investigating the flexibility of practices and, consequently, the shifting and shedding capacity of demand brought about by the 'un-braiding and re-braiding' (Trentmann, 2009) of everyday practice rhythms. This then opens a discussion for improved demand management policies in the respective socio-material contexts.

5.3. Method

This study focuses on a comparative analysis of two significantly different socio-material contexts in order to explore their relationship with the temporalities of practices for demand response in future smart development. The research was undertaken with the assumption that comparing similar practices in considerably different socio-material contexts provides greater insights into the socio-culturally embedded nature of practice temporalities.

As such, a comparison of household practices in empirical case-studies from Pakistan and Denmark provided a viable option; both countries have national objectives for smart-grid transitions with changing electricity provision systems but differ considerably in their existing socio-cultural context and material infrastructure. The empirical case-studies of household practices and energy demand for the two countries were conducted separately and form part of earlier published work (Friis and Christensen, 2016; Khalid and Sunikka-Blank, 2017). The Pakistan study formed part of an on-going PhD research at the University of Cambridge, UK, whereas the Danish study formed part of a household smart grid study at Aalborg University in Denmark. The original empirical research was not designed with the objective of a cross-cultural comparison, but the two available datasets

presented an excellent opportunity to compare time-shifting adaptability of household laundry practices under changing systems of electricity provision; the Danish households with microgeneration as a new form of energy provision and the Pakistani households with varying modes of electricity generation in an uncertain intermittent supply system. In both the Pakistani and Danish study, the empirical material focused on time-shifting and household energy consumption more broadly. This empirical data was revisited and re-analysed for the purpose of this study with a view to compare and contrast time-shifting of practices. Consequently, this paper focuses on detailed comparison of laundry practices.

The Pakistani study consisted of ten middle-income households in Lahore. Ownership of urban housing stock in Pakistan is concentrated in the middle- and upper-income bracket and constitutes majority of the urban domestic energy demand (Ghani, 2014). The interviewed houses in Lahore were detached, two-storey masonry structures with provision for house-staff, usually accommodating single or joint families (multi-generational family system is common in the culture). Houses were selected through strategic sampling on basis of variation in multiple means of electricity provision, including UPS (Uninterrupted Power Supply) systems, gas, diesel or petrol-run power generators and solar photovoltaics (PVs) in addition to utility power. Variation was also ensured in the type of family structure (single or joint family system), occupancy and education; all considered important sociodemographic factors that influence energy consumption. Data was collected through ten in-depth semi-structured interviews, with 21 interviewees, followed by walk-through house tours. Of these, six were joint family households with several generations living together (Table 9). Interviews were conducted in July-August 2016, which lasted for approx. 60-100 minutes. All interviews were recorded, translated from Urdu to English, transcribed, coded and analysed using NVivo.

From Denmark, thirteen semi-structured interviews, with 20 interviewees, were conducted in middle-income households in two rural areas of Denmark. All households had PV installation in combination with either heat pump, an electric vehicle or localised storage batteries. Households were selected with the aim of maximising the diversity regarding household size, age and occupation.[21]

The interviewed households in Denmark were primarily detached single-storey homes with single families, consistent with common family and housing structures in Denmark. Most households ended up being middle-class, dual-income families (only one family having parents younger than 30 years, as seen in Table 10), which reflects a demographic-based preference for investment in PVs. The

[21] Household selection was made in agreement with the two research partners (an electricity company and a public-private partnership working for decarbonising the local area) in two different areas: 31 houses took part in an EU-funded trial located on an island which tested a variety of smart-grid technologies in households. Of these, nine were selected for study, in which some combination of PVs with either storage battery or heat pump was found. Of the total 13 households that form part of this study, the remaining four (no. 10-14 in Table 2) were from another rural area, recruited on basis of PVs installed in combination with an EV.

interviews typically lasted for approx. 60 minutes and were conducted in Autumn 2016. All interviews were recorded, transcribed and later coded in NVivo.

Table 9: Household and Interview participant demographics from Pakistan

Interview Label	Interview Participants (Pseudonyms)	Household composition	Age of Interviewees (years)	Occupation	Electricity provision system
A	Mr. Asim	2 grandparents + 3 adult children + 2 grandchildren	60+	Self-employed/ Businessman	Utility + Generator
	Mrs. Asim		51-60	Housewife	
	Arif		20-30	Mechanical Engr.	
B	Mrs. Bashir	2 adults + 3 children	41-50	Housewife	Utility + UPS
	Bisma		20-30	Student	
C	Cyrus	2 adults + 2 children + 1 house-servant	31-40	Unemployed	Utility + UPS
	Mrs. Chishti		51-60	Housewife	
	Cemaal		20-30	Student	
D	Mrs. Dawood	3 grandparents + 3 adult children + 2 grandchildren	51-60	Housewife	Utility + UPS
	Duriya		51-60	Housewife	
	Dua		31-40	Housewife	
E	Mrs. Ejaz	1 great-grandparent + 2 grandparents + 3 adult children + 2 grandchildren + 3 house-staff	51-60	Housewife	Utility + UPS
F	Mrs. Furqan	2 grandparents + 2 adult children + 2 grandchildren + 2 house-servants	51-60	Charity worker	Utility + PV + Generator
	Fareed		31-40	Self-employed/ Businessman	
G	Mrs. Gulzar	2 adults + 2 children + 1 chauffer	31-40	Housewife	Utility + Generator
H	Mr. Harris	2 adults + 3 children + 1 house-maid	51-60	Agriculturist	Utility + PV + Generator
	Mrs. Harris		51-60	Small local business	
I	Mrs. Imran	2 grandparents + 3 adult children + 1 grandchild + 3 house-staff	51-60	Housewife	Utility + Generator
	Izza		20-30	Housewife	
J	Mrs. Jamal	2 grandparents + 6 adult children + 2 grandchildren + 1 house-maid	51-60	Housewife	Utility + PV + Generator
	Jamila		20-30	Student	

Owing to the diverse nature of background variables and multifarious characteristics among the two datasets, a straight-forward comparison would necessitate a reductionist approach. The qualitative sample of each country, however, presents a rich account of practice performances within the specific context of middle-class families in rural Denmark and urban Lahore respectively.

Table 10: Household and Interview participant demographics from Denmark

Interview Label	Interview Participants (Pseudonyms)	Household composition	Age of Interviewees (years)	Occupation	Electricity provision system
1	Mr. Danielsen	2 adults + 1 child	approx. 50	Blacksmith	PV
2	Mr. & Mrs. Larsen	2 adults + 2 children	41-50	Electrician & secretary	PV + battery
3	Mrs. & Mr. Petersen	2 adults	61-70	Health care assistant & retired workman	PV + battery
4	Mr. & Mrs. Hansen	2 adults + 2 children	51-60	Storehouse clerk & residential social worker	PV + battery
5	Mr. Beck	2 adults	approx. 60	Local director	PV + heat pump
6	Mr. Frederiksen	2 adult + 1 child	approx. 60	Production manager	PV + heat pump
7	Mr. Thomsen	2 adults	approx. 70	Inseminator	PV + heat pump
8	Mr. & Mrs. Svendsen	2 adults + 1 child	21-30	Haulage contractor & sales assistant	PV + heat pump
9	Mr. Olsen	1 adult	81-90	Retired technical director	PV + heat pump
10	Mr. & Mrs. Johansen	2 adults	71-80	Retired general labourer & head teacher	PV + EV + heat pump
11	Mr. & Mrs. Bertelsen	2 adults	61-70	Both retired school teachers	PV + EV + heat pump
12	Bjarne & Susanne Andersen	2 adults + 2 children	41-50	Both professionals (project manager and planner)	PV + EV + heat pump
13	Mr. & Mrs. Brodersen	2 adults	51-60	Doctor & nurse	PV + EV + heat pump

Furthermore, the close association of the authors with the respective culture ensured that the overarching sociocultural, political, economic and material frameworks were well understood, which formed the background for detailed empirical practice-based inquiry. Qualitative interviews are not meant for representative accounts of the studied subject, but provide rich and detailed descriptions of general value (B. Flyvbjerg, 2006; Kvale, 1996). Thus, the objective was to highlight the contextual significance of time-shifting everyday practices, for which even single examples that show variation would suffice.

5.4. Findings

The results of the analysis are presented, first, in terms of a general overview of the wide variations in the degree and extent to which homeowners adapt their daily routines to the changing electricity provision systems in the two contexts. This is then followed by a detailed comparative analysis of time-shifting of laundry practices.

5.4.1. A tale of two countries: general overview of electricity consumption

The primary reason for shifting and/or shedding of electricity consumption in Pakistan is the planned intermittent electricity supply system which results in daily power outages of 4-8 hours. Rearrangements in energy-use practices to accommodate the shifting magnitude and frequency of load-shedding schedules are common. Rinkinen (2013) highlights two types of rearrangements in practices during disruptions in energy provision; an orientation to embrace disruptions and one of seeking continuation for 'normality'. In the Pakistani dataset, both these rearrangements are seen to occur simultaneously prompted by the long-term inconsistent power supply.

Although dependency on an intermittent supply has made homeowners more flexible in their practice performances by shifting and shedding of electricity loads, it has, however, led to the emergence of a new material culture in households, that of seeking continuation and stability in practices. This is evident in the plethora of power back-up systems, such as UPS (Uninterrupted Power Supply) battery systems (which are highly inefficient and not subjected to any market regulations); diesel, petrol or gas-powered generators and, more recently, in the installation of PVs. Whilst such equipment makes energy more 'material' and its use more 'tangible' to homeowners (Strengers, 2012), it is also associated with convenience, a way of overriding the dependency and added complexity of time-shifting practices under the inconsistent power supply. The current energy regime not only dictates the temporal arrangement of practices in the interviewed households, but also at the wider community level; e.g. in determining when neighbours and friends can be visited and when grocery shopping can be done, depending on load-shedding schedules.

Contrary to the Pakistani sample, the interest in energy demand management and time shifting among Danish utilities and energy planners originates from growing shares of intermittent renewable energy production, specifically wind power, which now represents approx. 40% of the total Danish electricity consumption (Danish Energy Agency, 2017). This creates challenges of balancing electricity demand and supply due to the lack of synchronicity between production and consumption.

Up until 2012, Denmark witnessed a rapid growth in households installing PVs due to a favourable Danish tax regulation, which made it economically attractive to install PVs. This changed in 2012 with an hourly net metering scheme replacing annual net metering. Ten of the interviewed Danish households are on the hourly net metering scheme, and eight of these reported time-shifting some of their electricity-use practices to daylight hours to maximise use of self-produced electricity, thus providing an economic incentive for synchronising electricity consumption with PV production. However, in contrast to Pakistani households interviewed, the shifting of electricity-consuming practices is done on a voluntary basis, which has consequences for its penetration in practices as well as in society. This also means that time-shifting in Danish households is conditioned; several interviewees explained that if friends and family are visiting, dishwashing is not time-shifted.

In the Pakistani interviews, time-shifting was predominantly observed in practices related to comfort (ventilation and space heating/cooling), lighting and laundering (washing and ironing). In the Danish interviews, time shifting was especially brought up by interviewees in relation to practices of dishwashing and laundering. The following analysis will focus on and compare issues of time shifting laundering in the two contexts.

5.4.2. Time-shifting laundry practice in Pakistan

The intermittent electricity provision system was cited as the major reason for time-shifting of laundering practices by homeowners, who planned their daily routines and household chores around the power outage schedules;

> "We had to schedule when to do the laundry according to power outage times. We think about every part of our routine based on when the light (meaning electricity) will be out and when it will come back. We have to manage our entire day according to it. Everyone has done that." (Interview A)

For homeowners who can afford to have microgeneration through PVs, time-shifting was not a priority. In fact, a major reason for PV installation was convenience of having 24-hour electricity, comfort of cooling and non-reliance on electricity load-shedding schedules for performing practices;

> "Primary decision was definitely to get non-stop energy. We were getting 8-10 hours of load-shedding. 2.5 years back we installed them. My father and I am at work most of the day, but those at home had to face a lot of problems. Without energy, there is no life. Life just comes to a stand-still. Everyone has to wait for the electricity to come back- be it washing, cleaning, water coolers, even ironing..." (Interview F)

Laundering in the Pakistani middle-class households interviewed is a complex practice, involving multifarious resources. In all ten interview households, along with the use of washing machines on a daily to fortnightly basis, hand washing was common, particularly for delicate fabrics or children's clothing. In addition, in five of the ten households, washing and/or ironing of larger items and gent's clothing was outsourced. This is understandable considering the nuances of materials, colours, quality and textures of fabrics, each with its unique washing requirements, that make up the laundry in large middle-class families in Pakistani households, as indicated by Mrs. Gulzar;

> "All the gents' clothes, towels and bedsheets go to the *dhobi* (outsourced to washermen). The children's and my clothes are washed at home…sometimes by hand, and sometimes by machine. The machine is used once weekly. It's manual. Normally clothes are washed by hand by the servant, usually in the

> morning around 11am. I operate the machine myself, overseeing the washing by the maid. In the machine, I wash daily routine clothes, the everyday things. But special or formal clothes are washed by hand." (Interview G)

Outsourcing or hand-washing by house-staff point to the social dynamics at play in laundering and highlight that there is no need for time-shifting activities that do not rely on household electricity. When compared with the Danish interviews, a key point of distinction was that ironing formed a substantial part of the laundering process in all Pakistani households interviewed. Unlike washing, which is generally assigned a specific morning time-slot in most households, ironing was found to be more spread out. Three homeowners explicitly mentioned not using the iron in the evenings during peak hours to avoid higher electricity costs, while for the remaining households, timings for ironing very much depended on availability of house-staff or on a needs basis. Mrs Gulzar:

> "Ironing is done daily. These days it is used twice a day. All the clothes that are washed at home must be pressed. Once in the morning, around 10am, as per the amount of clothes. Then in the evening as well, around 5-6pm. It's done twice because of the heat, we generally have to change clothes twice daily, once in the morning and then once in the evening. In winters, its used only once, in the morning." (Interview G)

The wider cultural rhythms of society have a significant impact on the temporalities of everyday practices. A good example of this was provided by Mrs. Asim, who specifically avoids doing the laundry on Fridays, the day of congregational worship in Islam;

> Mrs. Asim: "I typically do the laundry daily, except for Fridays. We have a big family, so once daily is compulsory. On Fridays, I normally try not to use it."
> Interviewer: "Why is that so?"
> Mrs. Asim: "Because of the water issue. Everyone has to use water in the washrooms (because of Friday prayers) so I don't want there to be shortage. Also, all the attention is mostly concentrated on that. Even my cooking on Fridays starts after 3pm." (Interview A)

These examples show that laundering is a very complex and time-consuming process driven by social conventions of propriety and collective rhythms (Southerton, 2012; Mylan and Southerton, 2017) such as those of religious obligations, giving rise to social synchronisation (Walker, 2014). In this sense, laundering is not so much a 'personal' practice based on individual rhythms but becomes more of a social practice even in its very performance; through integrating various stakeholders, maintaining specific social standards and pertaining to social rhythms.

In addition to the wider socio-cultural context, daily routines, practices and management of household chores in the interviewed households in Pakistan were also found to be dependent on the type of family structures, roles and responsibilities of the various household members and the provision of house-staff. All these factors determine when and where laundering takes place in the household;

> "You can take it as…look…our electricity goes at 11:15am till 12:15pm, so we try to start it at around 12:30pm. It is definitely done in the morning because my maid comes around 11:45am, so we start the washing around 12:30." (Interview H)

The interviews indicated that the availability of house-staff played an important role in the temporalities of homeowners' practices. This has also been highlighted by Pfau-Effinger (2010), who compares the variations in arrangements of work and family life of southern European societies with their persisting tradition of a 'servant culture', with those of Scandinavian countries, where employed house-staff is frowned upon. Moreover, the availability of house-staff not only determines the temporal arrangement of practices in the interviewed households, but also influences the selection and use of appliances. Four of the ten interviewed households did their laundry using older, inefficient, semi-automatic washing machines and had no intentions of replacing them with newer, more energy efficient models as housemaids were responsible for laundering;

> "My machine is semi-automatic. That's why throughout, the maid I have is the one who is responsible for doing the washing… It is extremely old…very old. Almost every other day we have this discussion that it needs to be changed, it needs to be changed, but then I say that as long as it is in the hands of the housemaid…my friends tell me to discard it and be rid of the housemaid and to buy my own automatic machine… for one thing, I don't want to fire the housemaid, because she has been working here for a very long time. She proclaims that if you deduct my chores, I will leave you. I want to keep on doing these chores… as it helps increase her salary. That is why I don't buy an automatic…" (Interview H)

Since practices are dependent on such household dynamics, the availability of house-staff and the family structuring ensure temporal flexibility of practices, diffusing hot spots (Southerton, 2003) in time and space.

However, due to constraints of load-shedding schedules and time management required for the successful completion of chores, homeowners often talked about the sequencing and synchronisation required for performing practices. Four of the ten households specifically mentioned wanting a place for their washing machine in close proximity to their kitchen, as they preferred undertaking both

practices simultaneously. Since in most cases laundering was delegated to housemaids, it became easier for housewives to do the cooking while supervising the laundering;

> "…we selected the design for this house given the ideals and priorities of the time…I remember wanting the laundry area to be made adjacent to the kitchen. So that my washing and ironing area is right next door but separate." (Interview H)

Thus, temporal and spatial conditioning of practices gives rise to unexpected 'coupling constraints' (Ropke and Christensen, 2013, p. 54), which are then overcome by bundling (Shove et al., 2012) otherwise unrelated practices.

One critical trend that was observed in the Pakistani middle-class households interviewed was the gendered performance of practices that are time-shifted. Predominantly in the interviewed households, laundering, ironing and cleaning practices were performed by females, whereas the selection and purchase of household appliances and control of thermostat settings (e.g. in refrigerators and air-conditioners) were male-dominated practices;

> Mr. Fareed: "…my father and I, we are out most of the day, so everything in the house is being managed by the ladies of the house. We only come into play where some facilitation is required… In most cases, if an equipment (must be bought) or energy decision must be made, it comes from us, but what is required, comes from them… These are the decisions that we make…if they want a TV in their room, they would tell us that they want a TV, and we have to give it to them." (Interview F)

Hence, although men were seen to have more technical know-how, females were responsible for most of the time-shifting of practices to avoid 'peaky' (Strengers, 2012) evening electricity use such as in managing laundering and ironing practices.

5.4.3. Time-shifting laundry practice in Denmark

Among the various practices analysed in the Danish sample, it was found that laundering and dishwashing were being time-shifted by most households;

> "We also become more conscious about it, at the time we got the solar cells (PVs)… to consume power when we produced it ourselves… So, washing (laundering) and dishwashing, it was when the sun was shining…" (Interview 5)

Asked about the reasons for time-shifting electricity consuming practices, most interviewees refer to the economic benefit of being on the hourly net metering scheme; meaning that the PV power should ideally be consumed within the same hour it is produced. In addition, some homeowners liked the idea of using their "own" electricity, which relates to notions of being independent and self-reliant with energy;

> "Yes but, it is this mixture… It is about economy, but also this satisfaction with saying… What we are doing now, it's something we have produced our own power for… and what's weighting most, I don't really know…" (Interview 5)

Moreover, a few interviewees referred to environmental reasons like saving the environment or contributing to the "green wave" (Interview 6), that is, the transition of the energy system away from fossil fuels. However, environmental concerns seem much less prevalent compared to the attractiveness of using one's own energy, being self-reliant and (in particular) saving money.

In explaining why they chose to time-shift dishwashing and laundering specifically, several of the households taking part in the EU-funded trial referred to this being recommended by the project owners at a common information meeting at the start of the trial. This indicates that the trial setting also played a role in the participants' active engagement in time-shifting practices.

The time-shifting of electricity-use practices was closely interwoven with and dependent on the temporal rhythms of family life and household composition. In this regard, differences in time-shifting were found in households constrained by collective and institutional rhythms of school or work as opposed to those that were not. Predominantly, for those households where one or both (if a couple) adults were staying at home regularly during the daylight hours, e.g. due to retirement or one of the adults having night-shift work, the washing machine was started manually during the day. Mr. Thomsen, who is retired and typically stays at home during daytime hours provided one such example:

> Interviewer: "Okay, so … both washing machine and dishwasher are running during the daytime?"
> Mr. Thomsen: "Yes, that's the general rule."
> Interviewer: "Do you have a timer that you use?"
> Mr. Thomsen: "No, we are starting it (manually)"
> Interviewer: "It's because you are at home that you can do that?"
> Mr. Thomsen: "Yes, exactly." (Interview 7)

However, for those interviewed households in which the adult(s) are away from home during daylight hours (typically because of work), the washing machine is generally either started in the morning

(before they leave for work) or timers are set so that it starts in the middle of the day. Clothes are dried by hanging or using the dryer in the evening, once the homeowner's return;

> "Then (name of wife) leaves in the morning, so she can say (decide)… it (the washing machine) should start in 6 hours… or eight or 12 hours…" (Interview 5)

The interviews show that for dual-income households with daytime jobs, the time-shifting of laundering is highly dependent on automation and on the machines' capacity to run a full washing cycle independent of intervention (see also Friis and Christensen, 2016 for similar observations related to households' time-shifting energy consumption according to a static Time-of-Use trial). The use of timing devices for time-shifting practices has been found in other studies in the Global North (e.g. Mylan and Southerton, 2017). In the Danish households interviewed, with only one exception, no specific reference to ironing being time-shifted was made. This is not surprising, as the type of clothing culture prevalent does not require much ironing.

A point of significance highlighted during the interviews was how homeowners sometimes time-shifted (or postponed time-shifting) their laundering practices in relation to the weather forecast. By looking at the forecast for the next day, homeowners could decide whether enough solar energy would be produced to power the washing machine (or dishwasher);

> "If it has been cloudy or rainy weather, then we are not washing that day… As we are only two (persons) in the house, we do not need to run the dishwasher every day… we are trying to make it match with that the sun is shining…" (Interview 5)

These examples highlight how a household of only two members makes it less complicated to postpone laundering compared to households with children. This was also evident in the greater consistency of time-shifting practices in households without children living at home and, in particular, in homes with one or both partners retired from work, which alleviates the constraints of collective institutional rhythms otherwise imposed. The everyday life of households with children living at home are typically more time-pressured and with more distinct hot spots (Southerton, 2003) during the day (especially if it is a dual income family). Therefore, the time-shifting flexibility of these households is generally limited, as previously demonstrated by Nicholls and Strengers (2015) and Friis and Christensen (2016).

Another important aspect highlighted in the interviews was how time-shifting of laundering was not only related to concerns of synchronisation with PV power production, but also how sunshine and dry weather were associated with the possibility of hanging clothes outside. Dry and sunny weather was not only good for producing electricity but also for drying clothes. This simultaneity between

peaking PV power production and ideal conditions for air-drying clothes was also hinted at by Mrs. Petersen, who explained that they typically postponed laundering if they knew the weather would be good the next day, but that postponing laundering might be as much about good conditions for air-drying as it is about synchronising electricity production and consumption;

> "Especially if it is fine weather, the clothes are brought out to be hung… It's probably more the weather I'm thinking about, that it can be dried (outside)." (Interview 3)

These examples indicate that the habit of synchronising laundering with sunny weather is not entirely new, and that the introduction of PVs rather strengthens, or 'taps into', an existing habit than introduces a (completely) new routine. These findings also point to the importance of natural-social synchronisation (Walker, 2014).

The use of automation for time-shifting laundering was also seen to be dependent on seasonal regimes, as in the interview with the Svendsen couple. As both the household members had daytime jobs, they would shift between starting the washing machine manually in summers and using timers in winters. The difference was determined by the annual sun cycle with the sun rising early in the morning in summers, but later during winters. Since Mr. Svendsen typically got up at 2.30-5.30am, he would load and start the washing machine before he left for work in summers. His wife, who got up later, would hang the clothes before leaving at 8:30am. However, during the winters, Mr. Svendsen would set the timer so that the machine started in the middle of the day (when no one was home), and his wife would hang the clothes upon arrival home in the late afternoon.

During weekends, the institutional rhythm of paid work is absent in most families, which could imply a higher degree of flexibility in time-shifting consumption. This was indicated by the Svendsen couple, who mentioned postponing laundering generally to weekends. This also hinted at the gendered role of time-shifting. Mr. Svendsen explained how, on weekends, he typically followed the electricity production of PVs more consistently by reading the display of the inverter frequently, and if there was high electricity production, he suggested that his wife do the laundry:

> Mr. Svendsen: "… I'm just making sure that if we are having some laundry, that it gets started…
> Mrs. Svendsen: "And then it is me who have to get it started (laughing)…"
> Mr. Svendsen: "If she is having something that needs to be ironed, then she might as well do it then… Everything, that use power, it should be when the sun is shining…"
> Interviewer (speaking to Mrs. Svendsen): "Are you doing it, then?"

> Mrs. Svendsen: "Sometimes, yes… (Laughs) Sometimes I just say 'okay, okay, boss'… Or 'okay, okay, darling'… But it is not something I'm devoted to, if I'm going to be honest…" (Interview 8)

This example substantiates a gendering with regard to performance of practices that are time-shifted, with a female dominance as observed in similar studies (Treas and Drobnič, 2010b; Ellegård and Palm, 2011; Torriti et al., 2015; Anderson, 2016). Even though male interviewees also regularly took part in doing parts of the laundering, they were typically more engaged in monitoring the energy flows of the home and promoting synchronisation with the PV power production.

5.5. Discussion

The cross-cultural analysis of time-shifting everyday practices highlights the significance of developing future smart grid solutions and intelligent transitions with an understanding of the cultural and socio-material context of practices. The study shows that homeowners' practices are influenced by the varying electricity provision systems and, at the same time, highly contextualised and embedded within the wider socio-material and cultural context.

In Denmark, in the dual-income middle-class households interviewed, time-shifting laundering becomes difficult without timers and automation. In households with children, the practice becomes even more tightly bound in hotspots and wider institutional rhythms. Whilst institutional rhythms are found to play a greater role in defining household practices in the Danish interviews, the existing infrastructure with intermittent electricity supply greatly shapes practice temporalities in the Pakistani case. In the Pakistani sample, large family sizes and wider range of clothing materials mean that laundering and ironing is a much more complex, socially-bound and time-consuming process. However, the joint family system, provision of house-staff and outsourcing make laundering more flexible. Interestingly, this very system limits the applicability and usefulness of automation for demand management in Pakistan.

In the Danish households interviewed, the use of PV microgeneration for laundering through natural-social synchronisation means that the natural cycles of the sun and weather become an important constraint for homeowners. In the Pakistani interviewed households, laundering is predominantly a daytime activity, but requires flexibility and increased time for completion due to load-shedding schedules, hence often carried out simultaneously with cooking, creating new bundles and synchronisation in space-time between otherwise seemingly unrelated practices. In both Pakistan and Denmark, laundering is a female-dominated activity, which highlights the role that gender plays in management of practices and time-shifting.

An important point of contest in the two contexts is the volition of undertaking time-shifting of practices. In the Pakistani context, homeowners are bound to act in response to the administrative set-

up of the intermittent energy supply, whether by shifting or shedding their electricity-use or by incorporating back-up systems like PVs to get the convenience and comfort of 24-hour electricity; in contrast, the uptake of renewable microgeneration and time shifting are voluntary in Danish middle-class households and mostly motivated by ideas of saving money or increasing self-sufficiency. These differences affect the degree to which practices are time-shifted. In the Danish context, social obligations such as accommodating guests and visitors takes precedence over time-shifting; in comparison, the fixed load-shedding schedules in Pakistan have become an ingrained part of home life as well as community life. Visiting friends, grocery shopping or laundering are confined by the set schedules of the electricity provision system. Thus, the question of the extent of volition in demand management and response strategies, and how this reflects on local socio-material and cultural contexts, is important in policy frameworks for successful smart grid design. This also reinforces the co-constitutive and mutually shaping nature of temporality and materiality (here technology and infrastructure) in practice, as highlighted by Spurling (2018).

In the present cross-cultural analysis, using a practice-theoretical framework helped focus on the specific doings and in finding similarities across cultures in how practices formed bundles and synchronised with other practices. At the same time, it helped reveal differences in the ways in which this was achieved. Practice theories, specifically applied within studies of temporality, are not yet widely used in cross-cultural analysis. This study suggests, however, that they might be useful, as they bring to focus aspects of the local context which might otherwise be taken for granted. The 'systems of practice' (Watson, 2012) that define laundering in the Pakistani interviews are formed of very different elements of know-how, technologies, rules and engagements than in the interviewed households in Denmark. In addition, the respective socio-material setting results in very different timings, durations, frequencies and sequencing of performances. This can be seen, for instance, in the role of household staff and joint multi-generational households in the Pakistani interviews, compared to dual income, nuclear families in the interviewed households in Denmark, that determine time constraints and importance of institutional rhythms.

Having said that, applying practice theory to a cross-cultural comparison raises certain theoretical questions about the analytical boundaries of practice. If we concur with Shove and Pantzar's (2005) theorisation that practices can be thought of as socially and regionally situated performance, the present study would suggest that Pakistani and Danish interviewed households are, in fact, involved in two different practices, although with some ingredients in common. Even though similar ideas of cleanliness and washing might be at the core of laundry practices wherever they are situated, the different culturally and historically contingent socio-material settings result in different practices with different temporalities. Hence, further theoretical development in a cross-cultural context is needed to determine when a practice can be thought of as a 'collective convention' (Shove, 2003, p. 395) with shared understandings, and at what point do practices become socially differentiated entities.

Taking a practice-based approach to cross-cultural analysis further reveals that in smart infrastructure development, technology transfer alone from one country to another might not work. Narrowly defined demand management policies focusing only on technological appropriation and/or behaviour change through information fail to produce effective demand reduction (Shove and Walker, 2010; Strengers, 2013; Naus et al., 2014). For example, the empirical research shows how some Pakistani homeowners are reluctant to replace their old semi-automatic washing machines with more efficient automatic ones because of existing practices of labour division between homeowners and housemaids. The research shows that technology is embedded within practices which are also formed of other elements, including know-how, knowledge and engagements, which differ and interlink in different ways in varying contexts. The current study suggests that the effective 'diffusion' (Shove and Pantzar, 2005, p. 57) of smart infrastructure that is predominantly developed in the Global North to countries like Pakistan in the Global South would require a reframing of the existing electricity consuming practices. This would entail a transfer or (better still) broadening of other elements of the practice, as a form of 'reinvention' (Shove and Pantzar, 2005, p. 60) to incorporate different modes of engagement, practical and institutionalised understandings, in addition to technology transfer for improved efficiency and demand response. This presents a much greater challenge than the simple transfer of technology, including better understanding of the appropriation and adaptation of smart infrastructure within the specific socio-cultural context.

5.6. Conclusion

This paper used practice theories to analyse time-shifting of middle-class household practices and the resulting electricity consumption in the two significantly different cultural contexts of Pakistan and Denmark. While limited to a single sample in each context, the application of this theoretical approach to a cross-cultural context helped uncover the links between micro-level mundane household practices like laundering and the broader macro-level socio-material settings. The study revealed that time-shifting of laundering is not only dependent on material infrastructures of electricity provision, but also on social systems like joint family structures, 'servant culture' and clothing that is culturally and climatically appropriate. While practice theories were found to be useful in analysing temporalities of household practices in a cross-cultural context, further development is needed to conceptualise practices as shared or socially differentiated entities in varying local contexts in increasingly globalised future smart development goals.

The cross-cultural study illustrated how deeper and more direct connections are being forged between the changing electricity provision systems and daily household practices. These have implications for the shifting and shedding of electricity demand that can be expected and, consequently, the solutions proposed in smart-grid transitions as well as in the possible cross-cultural transfer of smart technology and demand response strategies.

For achieving energy savings and load shifting, different demand response strategies need to be developed for Pakistan and Denmark with regards to their wider systems of practice. While demand response strategies cannot be transferred between the two contexts in a simple way, there are still important lessons to be learned from the cross-cultural analysis. While the comparative study highlights the socio-culturally embedded nature of practices and their temporal-material arrangements, it also gives insight into alternative pathways that can inspire contextually-derived, less resource-intensive and more temporally flexible forms of demand. It also provides indication of strategies that may or may not prove successful in a specific context.

In the Pakistani middle-class households interviewed, smart infrastructure development based on automated systems and state-of-the-art appliances may not work. Instead, further encouragement of service-driven practices, like outsourcing laundering facilities, might be useful. In addition, since most washing takes place in the morning and early afternoon periods, along with cooking, demand response strategies need to focus on shifting ironing practices, as they are more resource intensive (as compared to the Danish case) and are often carried out in the peaky evening times. Learning from the study of Denmark, smart infrastructure development can focus on renewable microgeneration as a tool for self-sufficiency and can encourage utilisation of self-generated energy for household chores like laundering. This is supported by the hourly net metering scheme in Denmark, which incentivises consumption within the same hour of production. A similar approach could be encouraged in Pakistan with the recently launched local net metering regulations.

In the Danish sample, smart infrastructure design should focus on automated solutions for demand response, as these become essential for time-shifting, especially in dual-income households with children. Learning from the Pakistani experiences, one possible way that time-shifting could be made easier in Denmark is through encouragement of joint outsourcing or community-based facilities for laundering. This could, in turn, be supported by co-housing facilities that could further help reduce per capita consumption of single-occupancy households, which are becoming more common in Denmark. Moreover, in such joint or community-based facilities, certain domestic practices can be shifted to the service sector; in this way, the timing of laundering can be better controlled by implementing service sector demand response through smart infrastructure.

Some might question the relevance of comparing such different contexts like Pakistan and Denmark, but we believe that comparing such socio-culturally contrasting contexts is an effective way to make the established cultural and material structures, institutions and practices "visible". This is proven by the analysis of household practices that was undertaken in each case separately prior to this comparative study (Friis and Christensen, 2016; Khalid and Sunikka-Blank, 2017). While the individual studies highlighted significant characteristics of household practices, it was only through the comparative analysis that certain features of practice temporalities were brought to light. For

example, in the Danish case, the key importance of the dual-income family and automated washing machines for the temporal organisation and time-shifting of laundering practices were made visible by contrasting with the Pakistani case. In the Pakistani sample, the importance of servant culture in practice temporalities and use of appliances, in addition to the greater consumption of ironing as a significant part of laundering in contrast to the Danish case, were clearly highlighted. More importantly, the comparison emphasised that alternative socio-material arrangements exist, can show greater temporal flexibility and challenge existing norms and standards. For instance, the Pakistani sample that has been subject to time-shifting for decades shows that time-shifting and adapting to changing energy systems is both doable and realistic for Denmark, albeit as appropriated within the specific socio-cultural context.

As mentioned earlier, the empirical study was not originally designed for comparison and so presents limitations to the theoretically-derived inferences regarding the transfer of smart infrastructure technology. However, the examination of the temporalities of practices in each case is based on empirical evidence that reveal their strong interlinks and interdependence on socio-cultural norms and existing infrastructure. We strongly encourage further empirical research on the implementation and exchange of demand response strategies in smart grid development, specifically to address the gap in cross-cultural comparative studies that focus on socio-technical transitions. Furthermore, the cross-cultural comparison highlights how constraints of time-shifting are strongly embedded in family structures, and as these are expected to continuously change in the future of both Pakistan and Denmark, we are also reminded of how these constraints are never set in stone.

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References

Anderson, B., 2016. Laundry, energy and time: Insights from 20 years of time-use diary data in the United Kingdom. Energy Res. Soc. Sci. 22, 125–136. https://doi.org/10.1016/j.erss.2016.09.004

Aslam, W., Soban, M., Akhtar, F., Zaffar, N.A., 2015. Smart meters for industrial energy conservation and efficiency optimization in Pakistan: Scope, technology and applications. Renew. Sustain. Energy Rev. 44, 933–943. https://doi.org/10.1016/j.rser.2015.01.004

Bartiaux, F., Gram-Hanssen, K., Fonseca, P., Ozoliņa, L., Christensen, T.H., 2014. A practice–theory approach to homeowners' energy retrofits in four European areas. Build. Res. Inf. 42, 525–538. https://doi.org/10.1080/09613218.2014.900253

Buchanan, K., Russo, R., Anderson, B., 2015. The question of energy reduction: The problem(s) with feedback. Energy Policy 77, 89–96. https://doi.org/10.1016/j.enpol.2014.12.008

Chaudhry, T.T., 2010. Estimating residential electricity demand responses in Pakistan's Punjab. Lahore J. Econ. 15, 107–138.

Danish Government (2011). Energy strategy 2015- from coal, oil and gas to green energy, Copenhagen: The Danish Government.

Danish Government (2013). Smart grid strategy: the intelligent energy system of the future. Copenhagen: Danish Ministry of Climate, Energy and Building.

Danish Energy Agency (2017). Månedlig og årlig energistatistik, Energy statistics. Copenhagen: Danish Energy Agency. [Online] https://ens.dk/sites/ens.dk/files/Statistik/figurer2015.xlsx. Accessed 14 Mar 2017.

Darby, S., 2010. Smart metering: what potential for householder engagement? Build. Res. Inf. 38, 442–457. https://doi.org/10.1080/09613218.2010.492660

Durand-Daubin, M., Anderson, B., 2018. Changing Eating Practices in France and Great Britain: Evidence from Time-Use Data and Implications for Direct Energy Demand, in: Hui, A., Day, R., Walker, G. (Eds.), Demanding Energy. Springer International Publishing, Cham, pp. 205–231. https://doi.org/10.1007/978-3-319-61991-0_10

Ellegård, K., Palm, J., 2011. Visualizing energy consumption activities as a tool for making everyday life more sustainable. Appl. Energy 88, 1920–1926. https://doi.org/10.1016/j.apenergy.2010.11.019

Ellsworth-Krebs, K., Reid, L., 2016. Conceptualising energy prosumption: Exploring energy production, consumption and microgeneration in Scotland, UK. Environ. Plan. Econ. Space 48, 1988–2005. https://doi.org/10.1177/0308518X16649182

Flyvbjerg, B., 2006. Five misunderstandings about case-study research. Qual. Inq. 12, 219–245. https://doi.org/10.1177/1077800405284363

Friis, F., Christensen, T.H., 2016. The challenge of time shifting energy demand practices: Insights from Denmark. Energy Res. Soc. Sci. 19, 124–133. https://doi.org/10.1016/j.erss.2016.05.017

Ghani, J.A., 2014. The emerging middle class in Pakistan: how it consumes, earns, and saves, in: International Conference on Marketing. Presented at the IBAICM 2014, Institute of Business Administration (IBA) Karachi, Karachi.

Gram-Hanssen, K., 2014. New needs for better understanding of household's energy consumption – behaviour, lifestyle or practices? Archit. Eng. Des. Manag. 10, 91–107. https://doi.org/10.1080/17452007.2013.837251

Gronow, J., Warde, A. (Eds.), 2001. Ordinary consumption. Routledge, London; New York.

Hansen, A., Nielsen, K.B., Wilhite, H., 2016. Staying Cool, Looking Good, Moving Around: Consumption, Sustainability and the 'Rise of the South.' Forum Dev. Stud. 43, 5–25. https://doi.org/10.1080/08039410.2015.1134640

Heidenstrøm, N., Gram-Hanssen, K., Strandbakken, P., Toke Haunstrup Christensen, 2013. Changed norms of comfort in different energy cultures: The case of heat pumps, in: Rethink, Renew, Restart. Presented at the ECEEE Summer Study Proceedings, European Council for an Energy Efficient Economy (ECEEE), Toulon, pp. 2241–2249.

Higginson, S., Thomson, M., Bhamra, T., 2014. "For the times they are a-changin": the impact of shifting energy-use practices in time and space. Local Environ. 19, 520–538. https://doi.org/10.1080/13549839.2013.802459

IRENA, 2018. Renewables Readiness Assessment: Pakistan. International Renewable Energy Agency (IRENA), Abu Dhabi.

Irfan, M., Iqbal, J., Iqbal, A., Iqbal, Z., Riaz, R.A., Mehmood, A., 2017. Opportunities and challenges in control of smart grids – Pakistani perspective. Renew. Sustain. Energy Rev. 71, 652–674. https://doi.org/10.1016/j.rser.2016.12.095

Jack, T., 2013. Laundry routine and resource consumption in Australia. Int. J. Consum. Stud. 37, 666–674. https://doi.org/10.1111/ijcs.12048

Khalid, R., Sunikka-Blank, M., 2017. Homely social practices, uncanny electricity demands: Class, culture and material dynamics in Pakistan. Energy Res. Soc. Sci. 34, 122–131. https://doi.org/10.1016/j.erss.2017.06.038

Kvale, S., 1996. InterViews: An Introduction to Qualitative Research Interviewing. Sage Publications, Inc, London.

Matsuhashi, N., Kuijer, L., De Jong, A.M., 2009. A culture-inspired approach to gaining insights for designing sustainable practices, in: EcoDesign 2009. Presented at the Proceedings of the 6th International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Japan Society of Mechanical Engineers, Sapporo, Japan.

Mylan, J., Southerton, D., 2017. The Social Ordering of an Everyday Practice: The Case of Laundry. Sociology 003803851772293. https://doi.org/10.1177/0038038517722932

Naus, J., Spaargaren, G., van Vliet, B.J.M., van der Horst, H.M., 2014. Smart grids, information flows and emerging domestic energy practices. Energy Policy 68, 436–446. https://doi.org/10.1016/j.enpol.2014.01.038

Nicholls, L., Strengers, Y., 2015. Peak demand and the 'family peak' period in Australia: Understanding practice (in)flexibility in households with children. Energy Res. Soc. Sci. 9, 116–124. https://doi.org/10.1016/j.erss.2015.08.018

Pfau-Effinger, B., 2010. Cultural and Institutional Contexts, in: Treas, J., Drobnič, S. (Eds.), Dividing the Domestic: Men, Women, and Household Work in Cross-National Perspective, Studies in Social Inequality. Stanford University Press, Stanford, Calif, pp. 125–146.

Powells, G., Bulkeley, H., Bell, S., Judson, E., 2014. Peak electricity demand and the flexibility of everyday life. Geoforum 55, 43–52. https://doi.org/10.1016/j.geoforum.2014.04.014

Rinkinen, J., 2013. Electricity blackouts and hybrid systems of provision: users and the 'reflective practice.' Energy Sustain. Soc. 3, 25.

Rinkinen, J., Shove, E., Smits, M., 2017. Cold chains in Hanoi and Bangkok: Changing systems of provision and practice. J. Consum. Cult. 1–19. https://doi.org/10.1177/1469540517717783

Ropke, I., Christensen, T.H., 2013. Transitions in the wrong direction? Digital technologies and daily life, in: Shove, E., Spurling, N. (Eds.), Sustainable Practices: Social Theory and Climate Change. Routledge, Oxfordshire, pp. 49–68.

Schatzki, T.R., 1996. Social Practices: A Wittgensteinian Approach to Human Activity and the Social. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511527470

Schatzki, T.R., Cetina, K.K., Savigny, E. von, 2001. The Practice Turn in Contemporary Theory, 1 edition. ed. Routledge, New York.

Shove, E., 2003. Converging conventions of comfort, cleanliness and convenience. J. Consum. Policy 26, 395–418.

Shove, E., Pantzar, M., 2005. Consumers, producers and practices: understanding the invention and reinvention of Nordic walking. J. Consum. Cult. 5, 43–64.

Shove, E., Pantzar, M., Watson, M., 2012. The Dynamics of Social Practice: Everyday Life and how it Changes. SAGE Publications, London.

Shove, E., Trentmann, F., Wilk, R. (Eds.), 2009. Time, Consumption and Everyday Life: Practice, Materiality and Culture. Bloomsbury Academic, Oxford.

Shove, E., Walker, G., 2014. What Is Energy For? Social Practice and Energy Demand. Theory Cult. Soc. 31, 41–58. https://doi.org/10.1177/0263276414536746

Shove, E., Walker, G., 2010. Governing transitions in the sustainability of everyday life. Res. Policy 39, 471–476. https://doi.org/10.1016/j.respol.2010.01.019

Shove, E., Watson, M., Spurling, N., 2015. Conceptualizing connections: Energy demand, infrastructures and social practices. Eur. J. Soc. Theory 18, 274–287. https://doi.org/10.1177/1368431015579964

Southerton, D., 2012. Habits, routines and temporalities of consumption: From individual behaviours to the reproduction of everyday practices. Time Soc. 22, 335–355. https://doi.org/10.1177/0961463X12464228

Southerton, D., 2009. Re-ordering Temporal Rhythms: Coordinating Daily Practices in the UK in 1937 and 2000, in: Shove, E., Trentmann, F., Wilk, R. (Eds.), Time, Consumption and Everyday Life: Practice, Materiality and Culture. Bloomsbury Academic, Oxford, pp. 49–63.

Southerton, D., 2003. Squeezing Time' Allocating Practices, Coordinating Networks and Scheduling Society. Time Soc. 12, 5–25.

Southerton, D., Olsen, W., Warde, A., Cheng, S.-L., 2012. Practices and trajectories: A comparative analysis of reading in France, Norway, the Netherlands, the UK and the USA. J. Consum. Cult. 12, 237–262. https://doi.org/10.1177/1469540512456920

Spurling, N., 2018. Matters of time: Materiality and the changing temporal organisation of everyday energy consumption. J. Consum. Cult. 0, 1–18. https://doi.org/10.1177/1469540518773818

Strengers, Y., 2013. Smart Energy Technologies in Everyday Life: Smart Utopia?, 1st ed. 2013 edition. ed. Palgrave Macmillan, London.

Strengers, Y., 2012. Peak electricity demand and social practice theories: Reframing the role of change agents in the energy sector. Energy Policy 44, 226–234. https://doi.org/10.1016/j.enpol.2012.01.046

Torriti, J., Hanna, R., Anderson, B., Yeboah, G., Druckman, A., 2015. Peak residential electricity demand and social practices: Deriving flexibility and greenhouse gas intensities from time use and locational data. Indoor Built Environ. 24, 891–912. https://doi.org/10.1177/1420326X15600776

Torriti, J., Hassan, M.G., Leach, M., 2010. Demand response experience in Europe: Policies, programmes and implementation. Energy 35, 1575–1583. https://doi.org/10.1016/j.energy.2009.05.021

Treas, J., Drobnič, S. (Eds.), 2010. Dividing the domestic: men, women, and household work in cross-national perspective, Studies in social inequality. Stanford University Press, Stanford, Calif.

Trentmann, F., 2009. Disruption is normal: blackouts, breakdowns and the elasticity of everyday life, in: Shove, E., Trentmann, F., Wilk, R. (Eds.), Time, Consumption, and Everyday Life. Berg, Oxford, Oxford, UK, pp. 67–84.

Walker, G., 2014. The dynamics of energy demand: Change, rhythm and synchronicity. Energy Res. Soc. Sci. 1, 49–55. https://doi.org/10.1016/j.erss.2014.03.012

Warde, A., 2014. After taste: Culture, consumption and theories of practice. J. Consum. Cult. 14, 279–303. https://doi.org/10.1177/1469540514547828

Warde, A., 2013. What sort of a practice is eating?, in: Shove, E., Spurling, N. (Eds.), Sustainable Practices: Social Theory and Climate Change. Routledge, Oxfordshire, pp. 17–30.

Warde, A., 2005. Consumption and theories of practice. J. Consum. Cult. 5, 131–153.

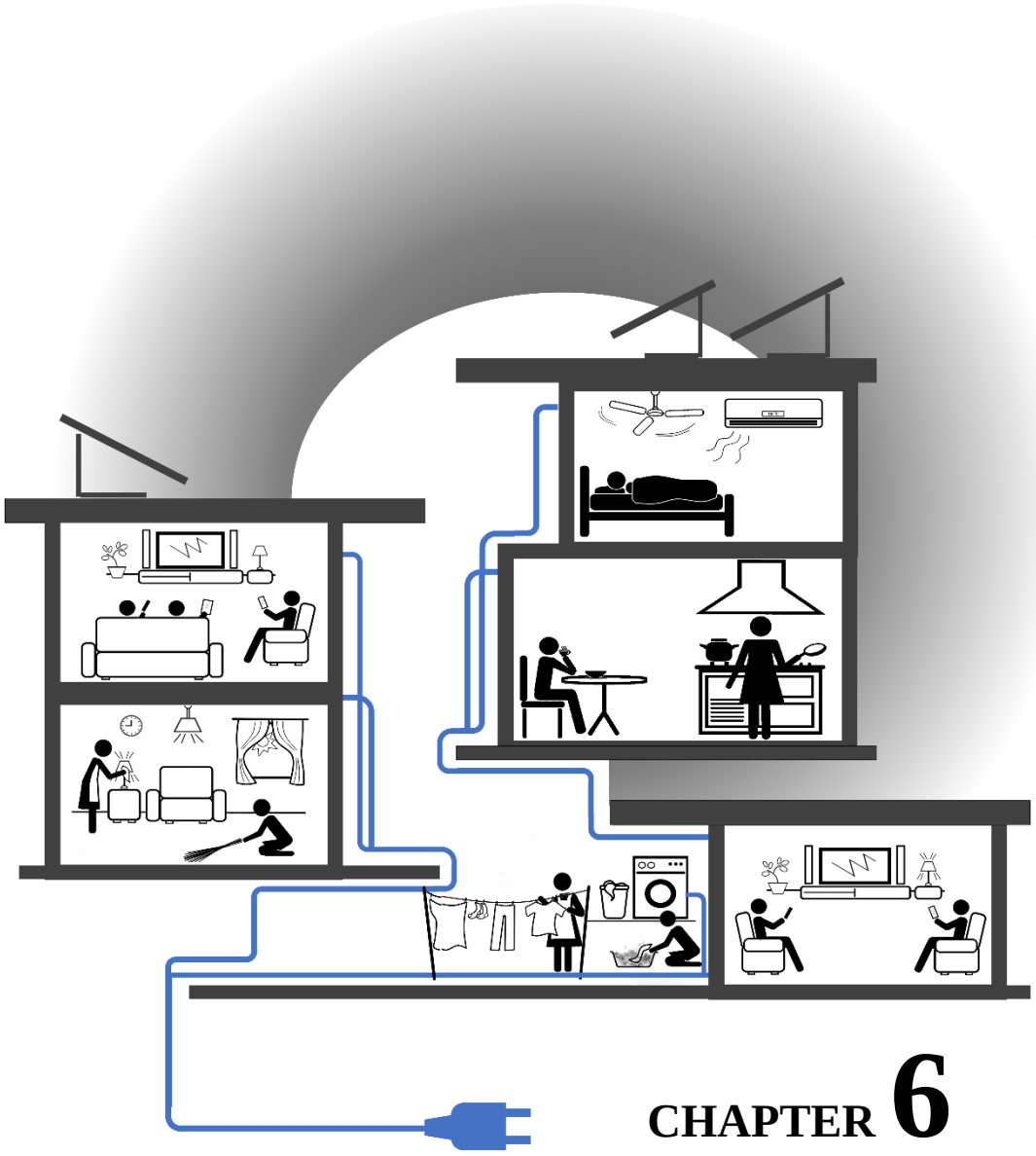
Watson, M., 2012. How theories of practice can inform transition to a decarbonised transport system. J. Transp. Geogr. 24, 488–496. https://doi.org/10.1016/j.jtrangeo.2012.04.002

Wilhite, H., Nakagami, H., Masuda, T., Yamaga, Y., Haneda, H., 1996. A cross-cultural analysis of household energy use behaviour in Japan and Norway. Energy Policy 24, 795–803.

PART III

PRACTICE AS UNIT OF INTERVENTION

Part III presents the second empirical section of the dissertation that explores practice as a unit of intervention in the design and use of houses. It consists of Chapter 6, which presents an investigation of architecture as a mediator of household practices. It goes on to explore the links between housing and household practices, mediated through the house design. It uses a practice-based intervention framework to explore how housing and household practices can be recrafted, substituted and changes made to how they interlock for low-energy interventions in the design and use of middle-class houses in Lahore, Pakistan.



CHAPTER 6

6. Practice for intervention in house design and use

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Abstract

This paper focuses on low-energy interventions in the design and use of houses from a socio-technical perspective. It explores the links between housing (design) and household (use) practices for sustainability transitions in middle-class housing in Lahore, Pakistan. Using two case-study houses as examples of variation in design, in addition to semi-structured interviews with housing practitioners, the paper investigates the transitions needed in housing practices that, through interventions in house design, can lead to less energy-intensive household practice-arrangements. It uses a practice-based intervention framework to explore how housing and household practices can be recrafted, substituted and changes made to how they interlock for improved sustainability. "Good" housing practices such as integration of more flexible, performance-based byelaws to meet minimum standards, better knowledge and skills of practitioners, good communication between stakeholders and the availability of low-carbon material supply chains can lead to "good" household practices, such as changed meanings of comfort, more outdoor-based activities and collective practice-arrangements. The paper thus highlights inadequacies of existing economically-driven, techno-

determinist efficiency models to meet required levels of housing energy demand. The practice approach makes the connections between "good" and "bad" housing and household practices visible and demonstrates their significance in identifying key areas of sustainability interventions.

Key words: Housing practices; household practices; low-energy house; sustainable transitions; practice-based intervention; sustainability

6.1. Introduction

Low-energy housing transitions are inevitable under rapid urbanisation, escalating energy demands and rising consumption of the emerging middle-class in the Global South (UNDP, 2013; EIA, 2016). During the first decade of the 21st century, the middle-class[22] in Pakistan grew from 32% to 55% of the total population and accounted for 90% increase in national consumption[23] (Ghani, 2014), specifically in urban regions. Although urban residential consumption is on the rise, estimates reveal a housing shortage of roughly 10 million units and the deficit continues to grow, particularly in the urban areas (World Bank, 2017). Pakistan's national housing policy remains inadequate in dealing with housing shortage under unprecedented urban population growth and poor environmental performance of existing housing stock (National Housing Policy Pakistan, 2001; Tiwari and Rao, 2016).

Most energy policies for low-energy transitions focus on economic rationale models and psychological behaviour change models (Shove, 2010; Strengers and Maller, 2015). In the building construction industry, either a technologically determinist paradigm dominates, or aesthetics take centre stage with architects considered as 'artistic form-givers' (Lorne, 2017, p. 268). While alternative architectural frameworks, such as user-centred design exist, such frameworks often take conventional needs for granted, reproducing high demands and maintaining the unsustainable status quo (Redström, 2006; Shove et al., 2007; Scott et al., 2012).

Instead, a socio-technical approach to societal transition has recently been advocated (e.g. Geels, 2002; Horta et al., 2014; McMeekin and Southerton, 2012; Shove, 2017; Strengers and Maller, 2015); an approach that moves beyond change at the micro-scale of the individual or isolated technologies to the interrelated social systems in place (Watson, 2012). In architectural practice, there has been similar critique of architecture representing autonomy or individual artistry (e.g. McNeill, 2006; Imrie and Street, 2014). Recent work in the sociology of architecture calls for spatial design and processes

[22] In Pakistan, the middle-class households are defined as having daily per capita expenditures of US$2-US$10 (in 2005 purchasing power parity dollars (Ghani, 2014)).

[23] Consumption here is understood as household expenditure on utilities and various commodity goods according to the Classification of Individual Consumption of Purpose (COICOP). This includes food, apparel, transport, housing and household goods, recreation and entertainment, education, fuel and lighting, etc, as expressed in (PBS, 2015) and measured in purchasing power parity dollars.

that prioritise socio-economic and cultural objectives (Lorne, 2017; Till and Schneider, 2012; Müller and Reichmann, 2015; Dutton and Mann, 1996). A socio-technical approach to low-energy housing thus considers buildings as not just grounds for technological efficiency in construction and appliances, but the 'material counterparts of competing social practices' (Guy and Shove, 2000, p. 67).

Most practice-based research on domestic energy-use has focused on practices of homeowners (see e.g. Hand et al., 2005; Ropke et al., 2007; Gram-Hanssen, 2008, 2011; Halkier and Jensen, 2011a; Maller et al., 2012; Foulds et al., 2013; Higginson et al., 2014 among others) and not of the professionals who design these domestic spaces. Such a one-sided approach creates gaps in the understanding of domestic energy demand and misses the critical links between housing and household practices for low-energy interventions. A broader understanding of low-energy housing as an intervention in a whole system of practice is required. This includes interrelations of many different stakeholders, including housing professionals, policy-makers, designers and builders as well as daily routines and practices of homeowners (Macrorie et al., 2015). Buildings as shared objects can play a central role in connecting practices of professional experts and homeowners (Jensen et al., 2014).

This paper investigates the links between housing and household practices as mediated through the house design. Using two case-study houses as examples of variation in house design, it investigates the transitions needed in housing practices that, through interventions in house design, can lead to less energy-intensive household practice-arrangements. Consequently, it explores potential practice-based interventions for low-energy house design and use applying Spurling et al.'s (2013) practice-oriented framework.

Section 6.2 explains the practice-based intervention methodology, followed by a brief review of the case-studies explaining how the house design mediates differences in household practice-arrangements. This sets the ground for the main findings in section 6.3. In section 6.4, the potential of practice-based interventions in house design and use is discussed. Conclusions are presented in section 6.5.

6.2. Methodology

6.2.1. Taking practice as unit of intervention

The call for closer engagement of Architecture with social theory for understanding societal transitions is not new (e.g. Dutton and Mann, 1996; Hatch, 1984; Knox, 1987). Despite its advocacy, there still exists a need for 'socially progressive architecture' (Lorne, 2017) that introduces new conceptualisations of spatial agency (e.g. Awan et al., 2011; Till and Schneider, 2012) and represents stronger ethical engagement with society (McNeill, 2006; Chan, 2015). Recently, socio-technical theories have become popular in architectural design in conceptualising agency of the built

environment in shaping social change through relationality (e.g. see Latour, 2005; Fallan, 2008; Latour and Yaneva, 2008; Yaneva, 2009 for an ANT approach and Gieryn, 2002; Müller and Reichmann, 2015 for a wider STS approach). These studies analyse the relationship between architecture and society to show how architecture as material artefact helps shape human action, mould decisions, change perceptions and mediate human relations.

Among practice theorists, the significance of architecture as materiality that shapes and defines social practices has recently gained focus (Guy and Shove, 2000; Kuijer and Watson, 2017; Rinkinen et al., 2015; Rinkinen and Jalas, 2017). In conceptualising societal transitions through changes in practice formations, Watson (2012) presents a 'systems of practice' approach, whereby multi-level systems and processes of transition persist and transform through the flow of practices. These practices reproduce the systemic institutions and relations at different levels, including those of public authorities, corporations, policymakers, marketing agents, maintenance and service sectors. Using this systems approach to analyse housing governance, Macrorie et al. (2015) posit that householders are just one set of carriers among many in a wider system of practices including those of housing professionals, designers and builders- all relevant targets for intervention. Similarly, Janda and Parag (2013) focus on building practitioners as 'middle actors' that can have top (government/policy makers), down (clients/consumers) and sideways (other building professionals) influence in improving building energy performance.

Taking practice as the fundamental unit for change towards sustainability, Spurling et al. (2013) have devised three intervention framings (summarised in Table 11), which will be used for exploring practice-based interventions in this paper.

Table 11: Framing practice-based sustainability policy. Source: adapted from Spurling et al. (2013, p. 15)

Problem framing	**Target of Intervention**	**Examples of policy reframing for sustainable housing**
1. Re-crafting practices	Elements of existing practices: • Images/Meanings • Skills/Competences • Things/Materiality	• Improved appliance efficiency • Improved environmental knowledge and skills
2. Substituting practices	• Competition between practices for time, space and resources • Encourage more sustainable variants of practice	• Designing cycle-racks instead of car-porches • Removing space for tumble dryer
3. Changing how practices interlock	• Infrastructure – *where* activities take place (practice synchronisation) • Institutions – *when* activities take place (practice sequencing)	• Home office- replacing mobility with virtual communication.

First, recrafting practices, changing parts of the practice to make it less energy intensive. In this case, the key is to introduce or remove elements so as to enable more sustainable forms of performance. This intervention only targets elements within practices, keeping practices themselves intact. Second is substituting practices, i.e. replacing unsustainable practice entities with more sustainable alternatives, such as providing spaces and places that allow performance of the more sustainable of two competing practices. Alternatively, more sustainable versions of existing practices might be encouraged. Finally, changing how practices interlock in space and time. Practices are generally interlocked in complex spatiotemporal networks and wider systems such that change in one can have ripple effects throughout the system.

Although the three practice-based framings proposed by Spurling et al. (2013) were designed for policy intervention, we propose that these framings can also be used to reframe housing and household practices for sustainability interventions in house design and use. As Spurling and McMeekin (2015) contend, such a framing questions the underlying need for current practices and opens it up for negotiation. In the present study, this framework helps to 'zoom in' (2015, p. 79) to examine individual components of household practice-arrangements and then to 'zoom out' (2015, p. 79) to the wider networks and systems that define housing practices.

6.2.2. Method

To understand the links between housing and household practices, we first explored variations in household practices as mediated through house design. The connection between household practices and house design was explored by undertaking two case-studies of contemporary middle-class houses in Lahore that represent two very different household practice-arrangement bundles. These formed the background for a detailed comparative analysis of current housing practices that mediate conventional energy-intensive household practice-arrangements (case-study1) with housing practices that allow less energy-intensive household practice-arrangements (case-study2). The analysis helped explore interventions in housing practices that can lead to low-energy house design and use.

A mixed method approach was adopted for collecting data. For a comprehensive understanding of current housing practices in Lahore, semi-structured interviews were conducted with 17 professional experts including 11 architects, 3 town planners and 3 builders/developers (Table 12). Further, a detailed analysis of housing regulations and policies was conducted. Additionally, a review of archival documents on building regulations, as well as analysis of house plans was conducted. Though beyond the scope of current research, it helped identify key themes for intervention in the present study.

Table 12: Details of professional interview respondents

Interview Label	Interviewee occupation/ designation	Company type	Age (Years)
A1	Chief Architect, Conservationist	Not-for-profit conservation company- National level, Medium scale (<500 employees)	55-60
A2a	Chief Architect	Architecture, planning & landscape design consultancy– Small-scale (<50 employees)	45-50
A2b	Chief Architect	- Same as above -	45-50
A3	Senior Architect	Not-for-profit conservation company - Medium scale (<500 employees)	35-40
A4	Chief Architect	Architectural, urban & engineering design consultancy. Small-scale (<50 employees)	40-45
A5	Chief Architect	Architectural design and planning consultancy. Small-scale (<50 employees)	40-45
A6	Chief Architect/ Academician	Architectural design and planning consultancy. Small-scale (<50 employees)	70-75
A7a	Architect and green buildings policymaker	Not-for-profit organisation focusing on sustainable buildings - National level, Medium scale (<500 employees)	35-40
A7b	Junior Architect	- Same as above -	20-25
A8	Chief Architect/ Academician	Architecture and building consultancy. Small-scale (<50 employees)	50-55
A9	Chief Architect/ Academician	Architectural planning and design consultancy. Small-scale (<50 employees)	30-35
P1	Director of Planning	Conservation & Planning division of local government authority	50-55
P2	Dep. Director of Planning	Town planning division of local government authority	50-55
P3	Assistant Director of Planning	- Same as above -	30-35
B1	Project Manager/ Building Engineer	Building construction & development company. National level, Medium scale (<500 employees)	35-40
B2	COO/Building Engineer	Design and build contractor. Small-scale (<50 employees)	30-35
B3	CEO/ Building Engineer	Architectural design and construction firm. Small-scale (<50 employees)	30-35

In-depth semi-structured interviews were conducted with case-study homeowners for comprehensive understanding of their everyday routines and practices. In addition, observation in walk-through house tours and time-use diaries were used for spatiotemporal mapping of household practice-arrangements[24]. A broader understanding of current conventional household practice-arrangements,

[24] In addition, quantitative data including temperature and humidity levels for environmental monitoring of various rooms of the case-study houses and monthly electricity consumption data was also collected but does not form part of the paper.

typical of the middle-class in Lahore, was part of the larger research project and has been previously published (Khalid and Sunikka-Blank, 2018, 2017).

The interviews ranged from 60-140 minutes. All interviews were recorded, translated from Urdu to English, and transcribed. Interview findings were coded and analysed using NVivo 11 (a type of CAQDAS- Computer Aided Qualitative Data Analysis Software). Finally, key areas of intervention in housing and household practices were identified using Spurling et al.'s (2013) practice-based intervention framework.

Case-studies provide context-bound knowledge and empirical evidence of the links between housing and household practices. Case-studies are generalisable to theoretical propositions and not to populations (Yin, 2014). In this research, they help explore theories for intervention, and not to extrapolate probabilities. Furthermore, atypical or extreme cases can highlight innovations or moments of transition, otherwise overlooked in representative samples (Bent Flyvbjerg, 2006). In this research, strategically chosen critical case-studies help identify links between specific housing and household practices. The selection of different cases would yield different ways in which housing and household practices interlock. Further, the objective of the paper is consciously focused on exploring rather than explaining how variation in housing practices can lead to variation in household practices and resulting energy consumption. To this end, this research helps initiate discussion for a practice-based approach to low-energy house interventions in the given context.

6.2.3. House design as mediator of household practices

To explore interlinkages between the house design and household practices, two critical case-studies were selected, and a comparison of their respective practice-arrangements made. The case-studies represent the middle- to upper-middle-class households in two different private housing schemes in Lahore. They are representative of the most common house plot sizes (250sqm- locally known as "10 marla" and 420 sqm- locally known as "1 kanal") within Lahore Metropolitan Area and cater to the middle- and upper-middle-class —the middle-class representing the major income group in Lahore (LDA, 2004)[25]. Since early 2000, most housing development in Lahore has catered to the middle- and high-income groups. This is because in 2001, under the growing pressure of housing backlog, the National Housing Policy revised the role of government as major housing provider to that of facilitator, empowering other stakeholders, specifically private sector and non-governmental organisations[26]. Semi-private and private corporations undertaking housing development have a

[25] Not to overlook the fact that increasing inflation and land prices have had consequences for the affordability of such housing even among the middle-classes. This has resulted in the gradual reduction of plot sizes over time, as evidenced in contemporary housing schemes (Khalid and Sunikka-Blank, 2018).

[26] As a consequence of changes in the National Housing Policy, the financial share of housing in public sector development has declined; from 10.9% in the First Five Year Plan to 5.9% in the Seventh Five Year Plan (MoHW, 2001). The private sector currently supplies around 200,000 houses per year (with the country facing

different agenda to that of public sector: as commercial actors, they tend to prioritise profit over affordable living.

The first case-study represents a conventional detached, bungalow-style[27] house (Table 13), a common typology in most contemporary middle-class housing schemes in Lahore. The case-study house was bought as-built by the homeowners. Following typical contemporary housing practices, the house was designed to meet market demand for aesthetics with complete reliance on mechanical means for comfort in the absence of passive design considerations. Hence, fans for ventilation and localised split air-conditioners for cooling are used extensively in summers. The house layout (shown in Figure 20 and 21), typical of most contemporary houses in Lahore, consists of a deep-plan configuration with maximised covered area, open-planned sitting (Figure 26) and superficial outdoor spaces (Figure 25).

Narrow peripheral outdoor spaces (Figure 20 and 25) are left open as per stringent byelaws of the housing authority that are more stringent compared to those of Lahore Development Authority (LDA), the main regulatory body responsible for planning and development in Lahore. Like most contemporary houses, the case-study house covers maximum permissible area, which is an important selling factor (Figure 20 and 21). This leaves little functionality of outdoor spaces and most household practices are performed indoors. There is greater individualised use of spaces due to localised cooling, enhanced by the absence of comfortable conditions in open-plan living spaces (Figure 20), all leading to increased energy intensity.

The second case-study represents a contemporary low-energy house (Table 14). The semi-detached house was designed as a climate-responsive building for improved thermal comfort with maximum provision for green outdoor spaces (Figure 24 and 27). Solar gains are reduced through improved insulation from roof garden terraces and extensive foliage on walls (as seen in the outer façade in Figure 4). The 22ft-high louvred boundary wall on the south-east (Figure 28) allows air to circulate while filtering out solar radiation. Although involving greater completion time (3 times that of typical house), the innovative house did not incur any additional costs in construction by employing revivalist techniques inspired from local vernacular architecture, such as arched structural walls (as seen in Figure 29) that reduce the quantity of brick and concrete required. The design also ensures lower maintenance requirements and cost-efficient comfort strategies. Seasonal thermal comfort is maintained through low-energy ground source cooling/heating, regulated through designated blowers and automated time control (Figure 30).

a backlog of 10 million housing units (World Bank, 2017)) and there are around 500-600 registered private developers in Pakistan.

[27] Referring here to the housing typology introduced to the Indian sub-continent during British colonisation, which included outward-oriented detached houses in a grid-iron planned urban layout. For further details, see (Khalid and Sunikka-Blank, 2018)

Table 13: Housing type and household demographics – Case-study 1

Figure 19: Case-study 1 house

Housing typolog and household demographics	
Housing type	Conventional post-modernist 2-storey house. DHA building regulations
Construction type	Load-bearing 9in (22.86cm) brick masonry 6in (15.24cm) R.C.C. floor slabs Single-glazing
Plot size	1 kanal (505 sqm)
Year of construction	1991
Covered area	70%
Green space	9-10%
Bedrooms	05
Occupants	07 M=4 F=3
Family structure	Single family (multigenerational)

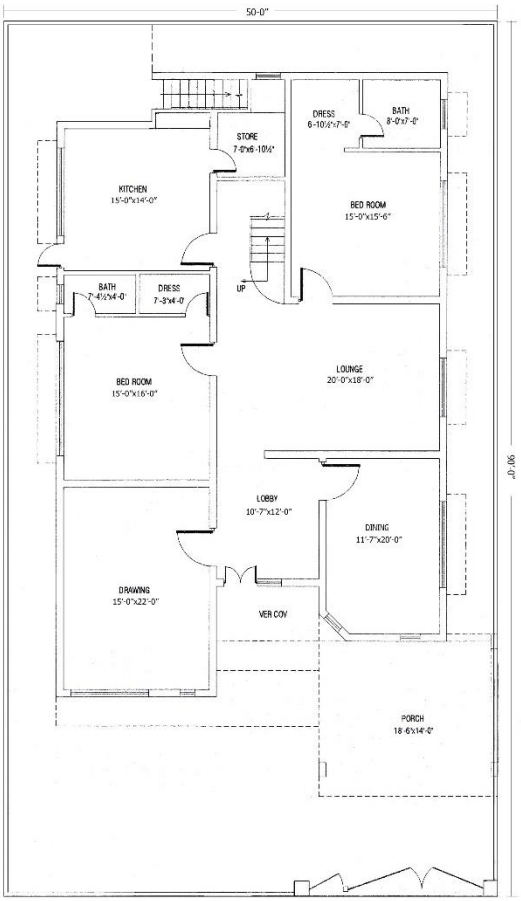

Figure 20: Case-study 1 Ground Floor plan

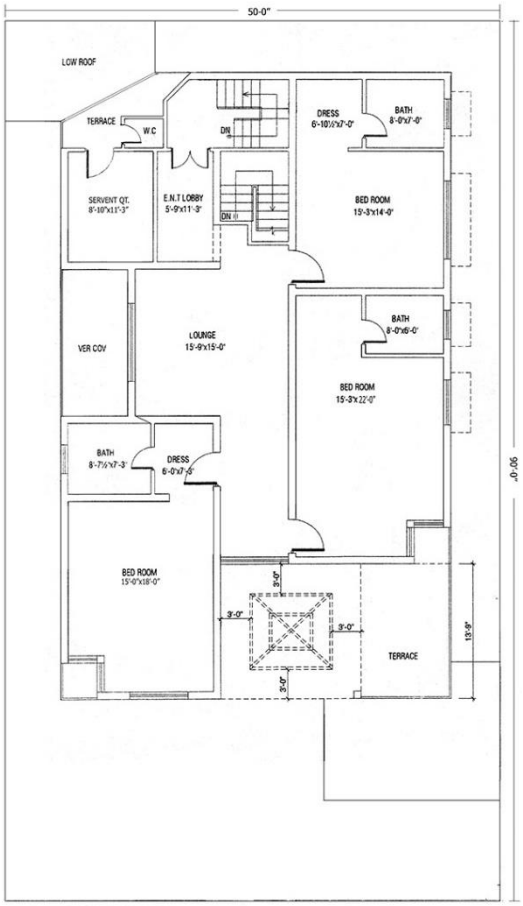

Figure 21: Case-study 1 First Floor plan

Table 14: Housing type and household demographics – Case-study 2

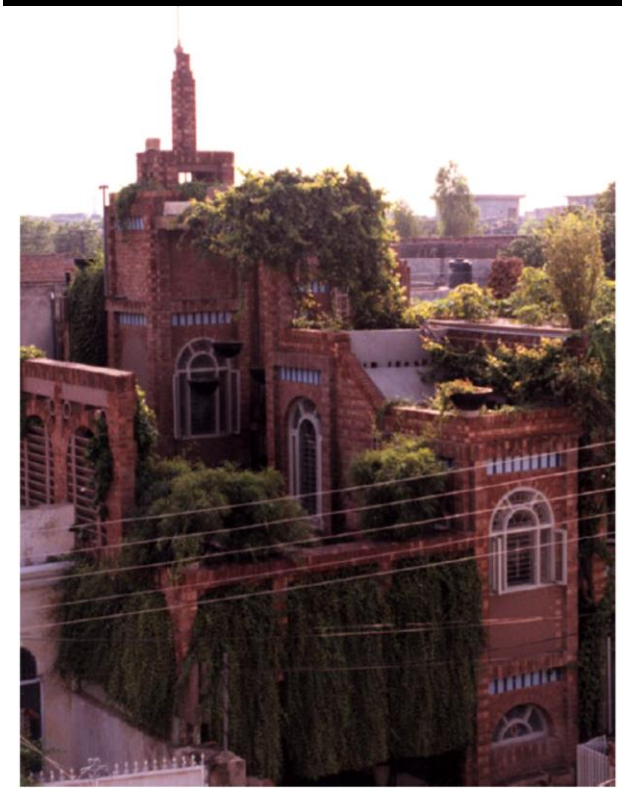

Figure 22: Case-study 2 house

Housing typolog and household demographics	
Housing type	Contemporary house with low-energy cooling technology. LDA building regulations
Construction type	Load-bearing 9in (22.86cm) brick masonry 1.5ft (0.46m) green roof insulation 3in (7.62cm) R.C.C. floor slabs Single glazing
Plot size	10 marla (~252 sqm)
Year of construction	1992
Covered area	75%
Green space	80%
Bedrooms	04
Occupants	07 M=5 F=2
Family structure	Single family (multigenerational)

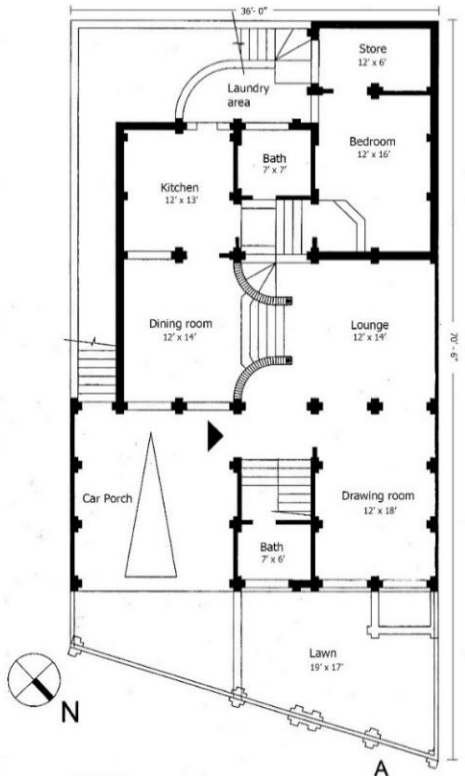

Figure 23: Case-study 2 Ground Floor plan

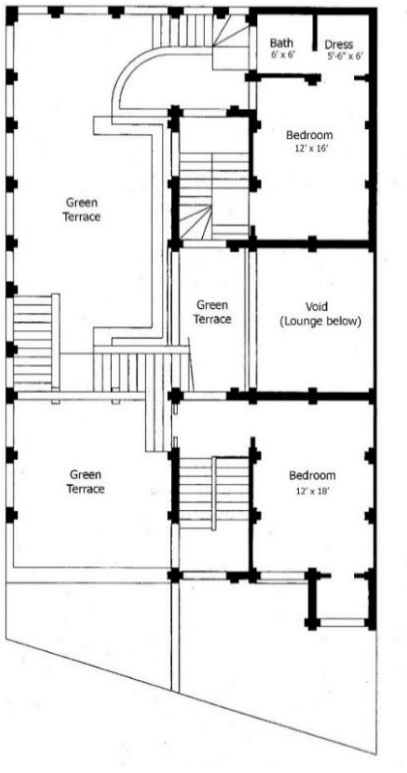

Figure 24: Case-study 2 First Floor plan

The house is predominantly based on an open-plan layout (as seen in Figure 23), a staple of modernist housing practices, in this case made thermally comfortable through a central low-energy cooling/heating system (Figure 30). The entire layout is planned on incremental split-level gradations between adjacent spaces (Figure 29), avoiding typical splitting of floorspaces into distinct levels, allowing a more organic and integrated flow between indoor and outdoor spaces. The 5ft-wide setback from the side and part of the 7ft-wide setback at the rear of the house (as shown in Figure 23) has been raised with infill, forming steps leading to the first-floor roof garden terraces.

Comparative analysis of household practice-arrangements in the two case-studies reveals how variations in the house design mediate different household practices. The low-energy house design mediates changes in comfort practices through the low-energy cooling/heating technology and more efficient insulation through roof gardens in two ways: First, this acts as a means of recrafting the material elements of homeowners' comfort practices; from conventional localised split air-conditioners to a more efficient technology that reduces cooling loads. Second, the reframing of homeowner's comfort practices is not just dependent on change in technology but is reinforced by the provision of a functional open-plan living space. In the conventional house design, where modernistic articulations propagate the demand for open-plan spaces, they can end up producing conflict with homeowner's need for comfort and privacy, often becoming non-functional in summers. However, in case-study 2, the low-energy cooling system allows homeowners to comfortably use the open-planned spaces of the living, drawing, dining and kitchen area on the ground floor. This has resulted in further strengthening the homeowners' negative perception towards conventional air-conditioning as a mechanism that isolates individuals and affects health and wellbeing through continued recirculation of air in enclosed spaces.

Spurling et al. (2013) contend that competing spaces for practice performance prefigure more or less energy-intensive pathways. With regards to competing indoor and outdoor spaces, indoor activities dominate in the conventional house, since most outdoor spaces are not designed for functional use (Figure 25). In the low-energy house, outdoor spaces are designed for greater use in household practices. Since 80% of the plot is covered with green spaces, roof garden terraces provide an exemplary space for outdoor activities like evening tea, play and relaxation, including space for growing vegetables and keeping animals (Figure 27). The house design thus acts as mediator for 'good', sustainable practices. In case-study 2, privacy in the roof gardens is ensured through a 22ft-high louvred boundary wall, separating the house from the adjacent property and giving privacy especially to female members of the household (Figure 28). Construction of high boundary wall was possible due to less stringent enforcement of building byelaws by LDA, allowing leeway for alternate spatial configurations in housing practices. Contrary to this, stringent byelaws in the conventional case-study housing scheme mandate maximum height of boundary walls and rooftop parapets to 7ft

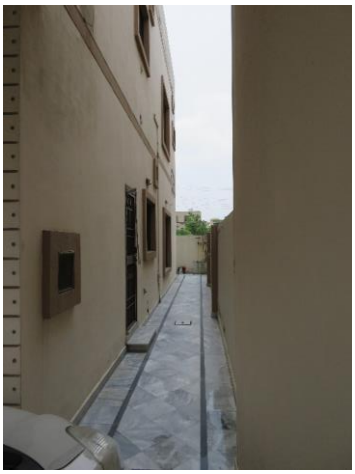

Figure 25: Narrow side passageway. Case-study 1

Figure 26: Open-plan living room. Case-study 1

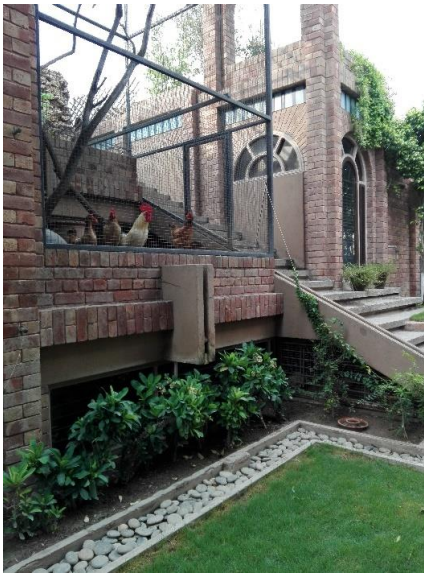

Figure 27: Roof garden. Case-study 2

Figure 28: Louvred boundary wall. Case-study 2

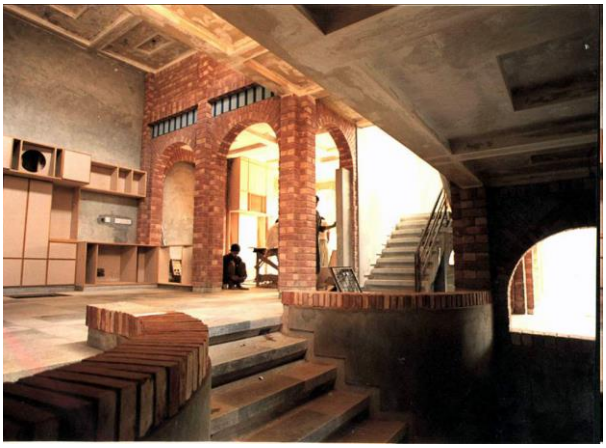

Figure 29: Split-level gradations between various rooms. Case-study 2 (Source: case-study 2 homeowner)

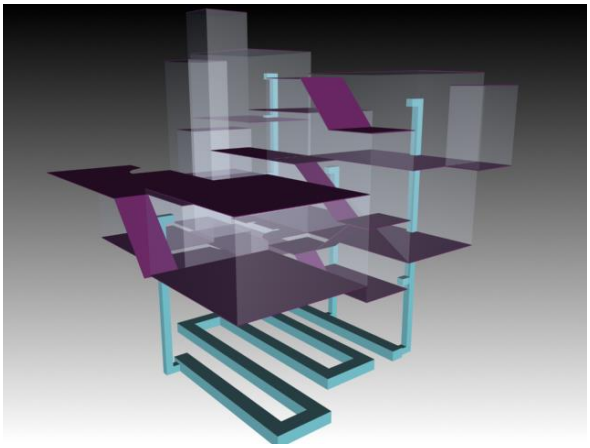

Figure 30: Illustration of the under-floor low-energy cooling/heating system. Case-study 2 (Source: case-study 2 homeowner)

and 3ft respectively, limiting privacy of outdoor spaces. The house materiality also has implications for more or less sustainable variants of a practice. In this case, variations in house spatial layouts in the two case-studies is indicative of performances of more collective versus individualised practices. Through the smooth flow of activities between spaces as evidenced in the split-level rooms in case-study2, more collective practices are prioritised and prefigured, with better use of multifunctional spaces. In case-study 1, rooms are larger in size and spaces are functionally individualised (e.g. kitchen, laundry area, dining, and living room). Consequently, practices become more spatially dispersed, leading to increased energy consumption. Hence, interventions in house design can also be used as obstacles for 'bad', unsustainable household practices.

6.3. Findings

In this section, we explore some of the housing practices linked with conventional household practice-arrangements (as in case-study 1) and compare them with those related to less energy-intensive household practice-arrangements (as represented by case-study 2) through analysis of interviews with housing professionals.

6.3.1. Impact of housing regulations and prescriptive byelaws

Housing regulations play a critical role in defining, shaping and prescribing spatial configurations and in doing so, mediate their design and use in housing and household practices. As posited by Chan (2015), building bye-laws can be seen as socio-technical artefacts, codes or value systems at the interconnection of design and household practices.

Most housing schemes in Lahore rigidly follow bungalow-style, outward-oriented, gridiron planning, initiated under the colonial rule and subsequently maintained by LDA. This limits flexibility in spatial layouts, as seen in case-study 1, resulting in neglect of solar orientation, micro-climate as well as cultural needs for privacy and segregation. Whilst building regulations have changed over time with gradually decreasing plot sizes and increasing covered area ratios, such changes are primarily driven by economic concerns under increasing land prices;

> "Increasing land prices mean most people cannot afford large plots with wide open spaces. They want to make the most of the land they purchase by maximising covered area and constructing as big a house as possible." (Architect, A3)

> "People even cement their front lawns now for more space. Every middle-class house has at least two cars that cannot be parked out in the street because of security issues." (Planner, P1)

Conventional household practice-arrangements further rely on increased space demands under the socio-economic image of conspicuous consumption and individualised practices. Such demands compel authorities to legalise increased building area in plots or to introduce compoundable violations through authorising penalties;

> "Byelaws change when there are many violations of the same kind- authorities cannot reprimand everyone. Byelaws are usually changed on a need basis: when owner's requirements change." (Planner, P2)

> "…in designing for maximum covered area, there wasn't any space left for natural light and ventilation in the basement. The authorities wouldn't allow it on paper, but realising that people need this space, they give verbal approval, and after construction, ask for the submission of revised drawings with penalty fees." (Builder, B3)

This points to conflicts between prescribed building regulations that mandate peripheral open spaces and homeowners' inclination of maximising the functionality of available space. This results in byelaws failing to account for functional private outdoor spaces (evident in case-study 1), suggesting that building regulations need to be designed differently;

> "Building regulations don't advise on best practices and sensible design choices. That's not what they are meant for. One drawback is that they don't incentivise practitioners to design efficiently and sustainably." (Architect, Interview A1)

Instead of restrictive spatial policies, regulations should enable evidence-based localised solutions and flexibility for innovation while maintaining minimum standards (e.g. area-oriented development in Dutch planning policy- Priemus, 2007). Performance-based building regulations can provide greater opportunities to accommodate socio-cultural needs (Becker and Foliente, 2005; Foliente, 2000) than prescriptive byelaws. Stringent byelaws, as in case-study 1, result in dysfunctional outdoor spaces that do not offer the necessary privacy and segregation required. By contrast, greater flexibility in byelaws and their custom-tailored implementation allow case-study 2 homeowners to maximise their potential space-use: the raised side passage and high boundary wall make the outdoor terraces private and functional. This shows that building regulations impact flexibility, or lack thereof, in the use of spaces and in substituting indoor with more outdoor household activities.

At the urban scale, planning regulations have direct and indirect impact on housing and household practices. Most contemporary housing schemes in Lahore are planned on an exclusive zoning format, where different building types are restricted to specific zones. Mixed-use or office buildings in residential zones are prohibited, restricting the types of spaces designed in conventional houses;

> "The client initially wanted a ground-floor office space. Byelaws don't allow commercial use of residential spaces, so it was converted into a formal drawing room alongside the existing dining and drawing (area)… There is an ongoing discussion about whether this entire space should remain open or portioned off into smaller units... it's the largest air-conditioning load in the house because of the open plan." (Architect, A7b)

Hence valuable space designed for mixed-use becomes redundant under exclusive byelaws. Such restrictions inhibit homeowners from pursuing professional practice from home, causing chain effects of increased mobility to workspaces, consequently resulting in more resource-intensive practice formations. Moreover, such stringent exclusive regulations also affect social structuring of the community, where uniformly sized plots permit residence only to affluent classes, inhibiting social inclusion.

6.3.2. Identifying change-agents in design and construction

In identifying change-agents for intervention in housing practices, the role of architects as experts in building design becomes significant. The low-energy case-study house involved engagement of the architect with the homeowners during the design process to understand their needs;

> "The house layout greatly depends on homeowner's preferences and lifestyle. Split-levels help create more living space that is open, flowing and interconnected. Conventional air-conditioning isolates users into enclosed spaces behind closed doors. In this house, interior spaces and exterior landscaped terraces facilitate family interaction." (Architect, A8)

However, most houses built in contemporary middle-class housing schemes in Lahore have no designer-user collaboration (as in case study 1). With the commercialisation and privatisation of housing schemes (see section 6.3.3), architects are left with a diminishing role in housing practices. Most contemporary private/semi-private housing authorities require architects to pay registration fees, greatly restricting their practice (see Figure 32), which is then driven by large-scale developers;

> "Architecture is a two-way street. Private architectural practices are greatly driven by clients' and developers' demands. We need to reduce energy consumption, but the demand is for modern houses entirely dependent on electricity. Those who cater to this demand make profits." (Architect, A1)

Case-study1 is an example of a built-to-sell house bought by the homeowners through a property developer. Although conforming to a key set of requirements for size and number of bedrooms, the

house had to undergo extensive retrofits to meet homeowner's needs. Even then, the open-plan living room remains too hot for comfort during summers.

Figure 31 shows a stakeholder chain diagram for various modes of house acquisition in Lahore. As shown, for most houses on the market, the link between homeowners as clients and architects as design experts often falls through in the process. Even if clients opt for self-built, their choice of architects is restricted to those registered with the specific housing scheme while the house design is restricted by the housing authority's stringent byelaws to "maintain a uniform front" (Builder, Interview B1). Architects are thus limited to aesthetical considerations in replicated, Western-inspired house plans;

> "Property dealers don't care about the quality or spirit of design, its efficiency or thermal performance. In fact, such businesses often don't involve architects at all. They keep replicating the same plans for profit… Property dealers and developers now dictate the house design… Huge windows are highly in demand. Afterwards, users add layers of curtains and complain about heat gains." (Architect, A4)

Although 'designed' by architects, such ill-conceived houses act as precedents and lifestyle inspiration for mass-produced housing, as indicated by interviewed practitioners;

> "People buy the (design) drawings for trendy houses from property dealers and get their own houses built on labour contracts." (Builder, B1)

> "Some clients approach us with internet-based references for their houses, especially the front facade… if they travel a lot, they give examples of hotels they've stayed in. They bring these bits and pieces they liked without really thinking of the bigger picture. They often ask us to blend the modern with traditional in unrealistic ways." (Builder, B3)

Janda and Parag (2013) highlight how the agency of middle-actors like architects in improving building performance is often weakened by work-related goals, lack of sufficient resources and need for survival. The interviews highlight similar constraints for architects and building engineers in Lahore;

> "Our primary effort is to convince the client for climate-controlled construction. If the client refuses, then we provide regular services and compromise to remain financially viable as a business and to survive." (Builder, B2)

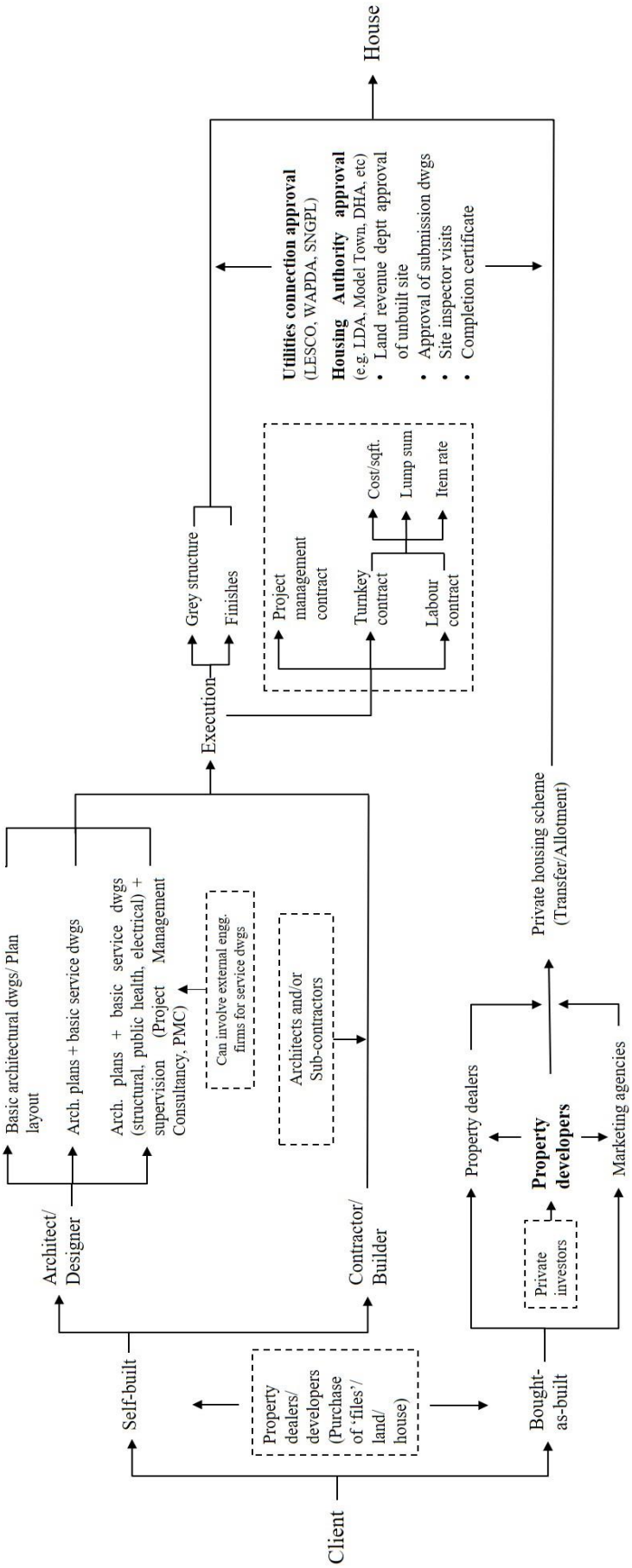

Figure 31: Stakeholder chain diagram for house acquisition in Lahore

Furthermore, the fragmented nature of the construction industry in Pakistan, as in Western countries, has made housing practices much more complex, involving multiple stages and stakeholders (Figure 31). Traditional housing practices relied on the triple C framework (Client, consultant and contractor) with individual small-scale projects often carried out with limited site-supervision. In large-scale housing development, proper site supervision and quality control become imperative. According to Farooqui et al. (2008), most construction projects in Pakistan face time delays, cost overruns, quality non-compliance and safety failures; almost 50% projects

receive warranty claims from dissatisfied client. Most clients do not involve contractors in the conceptual and design-procurement phases. Lack of proper three-way communication between the client, architect and contractor result in extra costs and time delays, as explained by one practitioner;

> "Initially, we supervised our (large-scale residential) project. Later, we asked the design consultants to supervise because of many issues- the contractor would say one thing, the design consultant something else, and something entirely different would get executed." (Builder, B1)

Such examples suggest that housing practices can benefit from a system integration approach (e.g. see (Yudelson, 2009; Shen et al., 2010) for effective collaboration in large-scale housing projects. Improved dialogue between stakeholders can enhance efficiency, cost savings, as well as user satisfaction.

Specialist skills, training and knowledge of low-energy design are also critical for sustainable transitions. When asked about low-energy design practices, most interviewed practitioners take a technological or 'spatial determinist' (Gans, 2002) approach to energy efficiency, believing in societal intervention through (re)design. A similar viewpoint is taken by governmental energy policymakers like the National Energy Efficiency & Conservation Authority (NEECA) and energy consulting firms like Pakistan Green Building Council (PGBC), and many private architectural practices. However, such an approach alone is insufficient to attain the rate, scale and scope of mitigation and change required (Anderson and Bows, 2011). In addition, this approach often overlooks higher initial costs, overall life-cycle costs and global climatic impact, while normalising and reinforcing energy-intensive practice-arrangements, as becomes evident in conversation with its proponents;

> "I believe even a glass house can be sustainable in Lahore … because the technology is there. High-performance glass, double-glazing, etc are now available. The selection and properties of the glass are very important." (Architect, A7a)

The use of high cost, energy-intensive materials is hence considered justified. Unsurprisingly, such approaches are often riddled with technological 'performance gaps' and behavioural 'value-action

gaps' through rebound effects (Khazzoom, 1980; Grubb, 1990; Saunders, 2000), resulting in ever-increasing demand. Focusing only on technological innovation and improvements in material efficiency misses the important links between the house design and everyday practices of users;

> "We design huge windows, but don't use them for air and light circulation. They are only meant for better views of surroundings. In most contemporary houses today, large windows are often closed off with thick curtains, green cloth or bamboo blinds for privacy." (Architect, A1)

This shows how the demand for large windows remains unquestioned and the need to rethink culturally inappropriate spatial layouts remains unchallenged. Such disparities between socio-cultural needs and Western-inspired design aesthetics result in conflicts with user practices, as found in case-study 1. The low-energy design in case-study 2 works because it combines the technological efficiency of the low-energy cooling system with the material efficiency of local fair-faced bricks using revivalist vernacular techniques in traditional structural patterns to improve thermal comfort with minimal energy-use. At the same time, the design layout ensures privacy and smooth flow of activities indoors and outdoors, broadening the understanding of energy efficiency to include socio-cultural considerations;

> "Inspired from traditional architecture, the house was designed using passive solar techniques to suit our needs and values. Roof gardens, planned as multileveled, interconnected, landscaped terraces provide attractive, easily accessible space for family use. The connection with nature is lost in the 'modern' houses of today." (Architect, A8)

One reason for the popularity of the energy-intensive conventional case-study house is the readily available skill set for its design and construction among professional practitioners. Even when designers and building engineers have knowledge of low-energy design, its execution is dependent on the skill set of the contractors and labourers. Without the expertise required for low-energy construction, operationalising innovation becomes difficult;

> "Our informal sector here in Lahore is still uneducated. House design has become a complex process and the contractors don't have the necessary training to accomplish the task." (Architect, A4)

> "More than the client, the contractors and the labour force are fixated on simply following their old conventional practices. It's very difficult to convince them to try something different." (Builder, B2)

One reason for this dearth of skills is the lack of demand driven, in part, by the perception of energy efficient design as a premium service with higher costs and reduced affordability, by practitioners and users alike. Sharp (2009) contends that the perception of green buildings as too expensive is based on a range of failures in the design process, rather than failures intrinsic to the concept of greening buildings, such as costs for learning skills and revisions resulting from incompetence. The low-energy case-study house was built with no additional costs of construction, using T-beam R.C.C roofs and arched windows that reduced concrete use, even with the addition of roof terraces and the underground tunnel for cooling. However, the dearth of skills required for low-energy construction as well as perceived higher costs prevent its mass-scale deployment.

Recrafting the skills necessary for implementing low-energy materials and techniques also depends on ensuring ready and cost-effective market availability of such materials, as highlighted by the interviews;

> "In 2005, energy efficient windows were introduced in Pakistan... people became aware of the window types and functional properties that reduce heat gains and improve insulation and airtightness. Gradually it gained momentum. Cost-effective varieties started to appear in the market." (Architect, A4)

Absence of residential building energy certification schemes and mandatory nation-wide energy labelling for appliances and technologies in Pakistan has resulted in limiting market availability and use of efficient material components in housing practices. Without the necessary supply chains and logistical arrangements, replacing conventional materials with low-energy alternatives is fraught with difficulties; not only in installation, but also procurement and transport;

> "We aimed to replace cement with fly-ash, a waste by-product, to reduce our project's carbon footprint. We located the fly-ash in another city. Because it's very fine, transporting it to the site became a nightmare. We had to use water bowsers…can't be dumped on site, it will fly away. Fly-ash is extremely cheap, almost free, but with the transport and equipment costs… we just broke even." (Builder, B2)

6.3.3. Changing ideals of home

This section explores the relationship of the housing practitioners with their clients, from these professionals' perspective. According to the interviewees, housing practices are subject to the social acceptance and symbolic derivations of homeowners' lifestyles, norms and ideals of home;

> "It's the norm now to display wealth through your house. Till the '70s and '80s, it wasn't considered appropriate to spend too much money on the appearance

> of your house. Architecture is now a social-status symbol, a marker of identity. People spend a lot of money on beautifying their house facades." (Architect, A1)

Architecture as a symbolic representation of class, stature and wealth has become a social staple in contemporary Pakistani society (see e.g. Ghani, 2014; Khalid and Sunikka-Blank, 2017; Qadeer, 2006). This 'conspicuous consumption' (Wilhite and Lutzenhiser, 1999) serves as a visual display of 'the judgement of taste' (Bourdieu, 1984). The 'spatialization of class' (Zhang, 2010, p. 107) and rising consumption in middle-class households is not unique to Pakistan but also observed in other parts of the Global South (see e.g. Browne, 2016; Hansen et al., 2016; Sahakian, 2014; Smits, 2011; Wilhite, 2008). Such symbolic connotations mean that aesthetic considerations often win over competing requirements of passive techniques for sustainable design;

> "Nowadays, it's common for clients to demand two kitchens. A larger, expensive, state-of-the-art kitchen for the housewife and a smaller, utilitarian kitchen at the back as a 'dirty kitchen', where the hired cook does the actual cooking and dishwashing. Result is that crucial space needed for outdoors, proper ventilation and day-lighting is eliminated." (Architect, A2b)

This is also evident in other socially necessitated formal spaces that, although functionally redundant, are essential for upholding social customs and ostentatious display;

> "There are many redundant spaces in our houses today like drawing and dining rooms, which are only used occasionally. This means there is no functional outdoor space anymore. As architects, even if we refuse to design drawing rooms, our clients demand that they must have a drawing room because their parent's house had one as well" (Architect, A2a)

Social setup of joint family structures together with increasing land value result in middle-class homeowners maximising their indoor spaces;

> "Contingency planning for additional family members, multi-generational living and frequent long visits from extended family mean that needs are considerably multiplied and hence, house spaces are multiplied." (Architect, A2a)

> "…they plan for contingencies in the future…. Secondly, people are now much more open to providing separate spaces for their sons' families. Society dynamics are changing. Parents now realise that the present generation will no longer tolerate interference. Moreover, children, even young couples, realise

> that they cannot afford to live separately due to inflation and increased land prices." (Architect, A1)

These examples highlight that housing practices are bound by (sometimes conflicting) wider social and cultural norms and customs, which restrict planning and design flexibility.

Along with changing ideals of home driving energy-intensive housing demands, the interviewed practitioners also highlighted how the concept of house is changing;

> "There are two types of houses being designed today: One is custom-designed by the architect for a client, in keeping with their requirements and basic rules of orientation and passive design. These form a very small minority of housing. The dominating type is the one built by the developers for private housing schemes on a commercial basis for selling." (Architect, A1)

Figure 32 shows the various change-agents involved in the wider system of housing practices. As shown, the role of end-user as a client is increasingly being replaced by a commercial developer. This changing nature of the client, from a homeowner and end-user to a property investor and real-estate developer has resulted in the re-conceptualisation of the house, from 'a means to provide shelter' to 'a means to generate financial returns' (Graaf, 2017, p. 421). De Graaf (2017) has highlighted this fundamental shift in the role of buildings resulting from the privatisation of housing under capitalism where 'a building is no longer something to use, but to own' (2017, p. 421) as a form of financial investment, similar to evidence from interviewees;

> "Most of these houses are used show-houses by the rich. They use them for short durations, mostly when visiting from abroad. This also means that the community does not function the way it should- as a community, a neighbourhood." (Architect, A1)

> "The reason our company launched the smaller 3.5 marla (~950 sq. ft) plots was to ensure that people had buying power. Many people buy these houses as investments on fixed monthly instalments. Since a non-filer[28] cannot buy a plot that is more than PKR5 million, they can buy two of these smaller plots." (Builder, B1)

[28] A non-filer is a person who has not filed their annual tax returns.

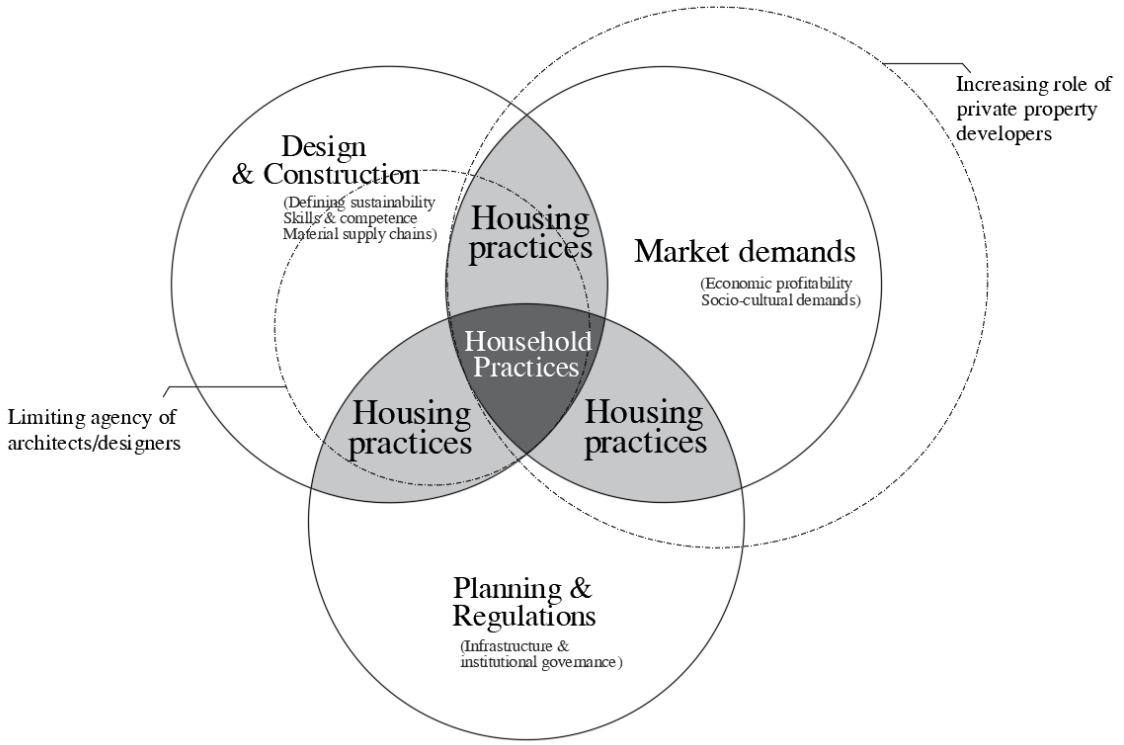

Figure 32: The wider system of housing practices in Lahore

Architects and property developers alike are increasingly taking over the role of the client and dictate what should be designed based on what sells and makes profits rather than how it will be used and lived in. The use of the house is now no longer residential, but commercial;

> "There are numerous architectural practices in Lahore where they are both the client and the designers, as they build houses to sell. Many architects find this more profitable." (Builder, B1)

> "The general rule of thumb is- if a developer sells approx. 30-35% plots in the (housing) scheme, they will recover 100% of their capital investment. The rest is profit. Another important thing is the current market scenario which depends on the current rates. You can 'hold' a plot for a certain time. As the land value increases, that becomes your profit over time." (Builder, B1)

As the concept of housing changes from providing living space for end-users into an asset of maximising profits, it's design no longer conforms to the functional requirements for space and the cultural affordances of the end-users;

> "It started with the commercialisation and privatisation of housing development. Those who are building houses for their personal residence usually prioritise structural integrity and construction quality. Those who are

> building to sell usually cut corners wherever possible to maximise profits" (Architect, A1)
>
> "These days, better-looking houses are easier to sell. In this, the show of electricity consumption is a selling point; it must appear very 'modern' and 'innovative' to maximise profits. When this becomes the trend, then everyone else, whether they are building to sell or not, simply follows suit." (Architect, A9)

This means that production and consumption goals can often end up conflicting. The dominance of the "global corporate capital as the embodiment of power, authority and autonomy" can generate consumption by "inventing certain demands paradoxically contradictory to demands for sustainable living, escalating towards a point of no return." (Architect, A6). The demand for housing is driven by the market, in which advertising agencies now play a key role;

> "The marketing agency wanted us to reduce the cost of our designed apartments. We had to compromise on the finishing to reach an agreement with the marketing agency; a figure they could work with to attract customers and sell the apartments." (Architect, A2)
>
> "Initially, we managed marketing ourselves. But now, we have hired a marketing agency. They provide input right from the design stage, because they tell us whether something will sell at the specified design costs." (Builder, B1)

Hence, housing practices are locked into wider systems of practice at the infrastructural and institutional level that govern housing development and need to be accounted for in low-energy transitions.

6.4. Discussion

This study This study presents an analysis of housing practices and their implications for the design and use of middle-class houses in Lahore. The two case-study houses represent conventional energy-intensive versus low-energy household practice-arrangements as part of broader housing practices. Using the systems of practice approach, the study identifies links between 'good' and 'bad' housing and household practices and resulting energy demands, as shown in Figure 33. Spurling et al.'s (2013) framework (see Section 6.2.1) is applied to investigate how conventional housing and household practices can be 'recrafted', 'substituted' and 'changes made in how they interlock' for low-energy transitions.

Housing practices in Lahore, though reliant on technologies and infrastructure, also depend on the skill-set and competences of the practitioners as well as the meanings associated with 'ideal' housing,

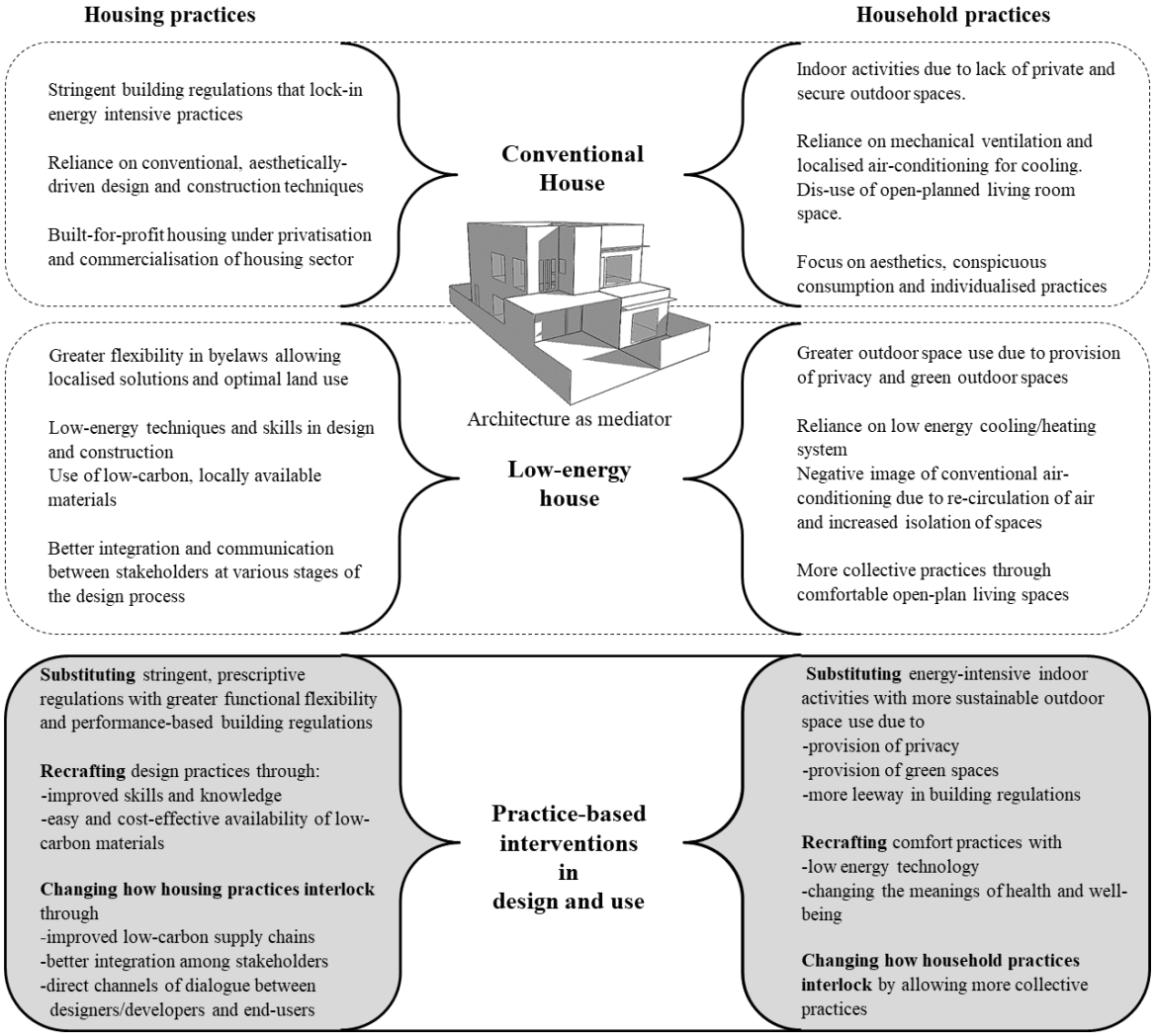

Figure 33: Interlinking housing and household practices in the two case studies and practice-based framework for interventions in design and use

'good' design and appropriate household practices. Whilst improvements in construction techniques and building materials can improve the efficiency of house building, it may not lead to interventions in household practices. Case-study 2 shows how innovative low-energy solutions and spatial configurations changed household practices when combined with 're-crafted' knowledge and skill-set of the practitioners and homeowners' changed meanings of comfort. This challenges the notion of sustainable development that only focuses on technological efficiency, locking-in existing societal systems (Loorbach et al., 2017) without questioning established norms, such as accommodating inherently inefficient bungalow typology (2013). It is only by actively 'substituting' housing and building regulations that continue to prefigure unsustainable practices that assumptions about "good" living and lifestyles can be changed. Reframing building codes that advocate 'ethics of sustainability' into conventional understandings of 'ethics of responsibility' (2015, p. 206) can help substitute conventional with low-energy design practices. In the case of Lahore, some of the challenges identified in the path towards low-energy transitions can be overcome by various forms of interventions in the whole system of existing housing practices (as shown in grey in Figure 33). For

example, promoting and normalising the use of more efficient, sustainable and local materials through subsidies and tax incentives, incorporating knowledge of alternative and/or traditional construction skills and techniques in architectural education and integrating performance-based regulations in building and planning policies that promote greater outdoor space use, ensure privacy and smooth flow of indoor-outdoor activities. The integration of regulations, byelaws and housing market trends show that low-energy interventions can be made through targeting the housing practices of not just architects, but various other stakeholders involved. Guy and Shove (2000) highlight this embeddedness of housing practices within wider social and technical networks of governance where design specifications are driven by the industry's sense of market demand. Just as they emphasise the role of 'non-energy considerations' (2000, p. 67) in determining overall energy demands, so can 'non-architectural' considerations, such as capital investments and privatisation (Haque, 2000; Bajwa et al., 2008; Anis-ur-Rahmaan and Anis, 2009), influences of globalisation (e.g. King, 1984, 1990), socio-politics (e.g. Knox, 1987; Bajwa, 2013; Bhan, 2017), cultural contexts (Bourdieu, 1970; Powell, 1985; Khan, 1994) and user demands (e.g. Khalid and Sunikka-Blank, 2017; Janda, 2011; Ahmed, 2016), be thought of as contingent on architectural housing practices (see Figure 32).

The analysis shows there is a need for 'changing how housing practices interlock' during the design and construction process. The changing nature of the client, from the user to the developer/private investor has resulted in disconnecting the design of the house from its actual use, with primary focus on aesthetics and profitability. Housing practices need to reintroduce the link between homeowners and architects with an integrated understanding of users' daily practices by creating dialogue between the designers/developers and end-users. As Yudelson and Meyer (2013) contend, a true integration of the design process would include future operators and occupants of the project. Further, as housing practices are formed of a complex web of various stakeholders, material infrastructures and institutional regulations, for a system transition there needs to be better integration of the various change-agents involved. Macrorie et al. (2015) contend that the success of interventions in practice relies on identifying the network and flows of interconnected practices. This suggests that interventions in housing practices will only work if undertaken with a wider system approach. In this regard, recent changes in property taxation laws (FBR, 2018) that enforce higher withholding taxes and higher taxes on capital gain in property transactions for non-filers is a positive step for regulating real-estate business in Lahore.

The analysis shows that in a mutually dependent process, "good" housing practices can feed back into the system so that they shape, guide and mediate "good" household practices; while "good" household practices can help reinforce and reproduce the market demand and knowledge for systems of "good" housing practices. Similarly, the framework can be used for hindering "bad" household practices through disrupting their 'circuits of reproduction' (Shove et al., 2012) in the system of housing practices.

6.5. Conclusions

This paper set out to explore the links between housing and household practices as mediated through the house design, in the context of Lahore, Pakistan. The analysis of housing practices and their implications for the design and use of a low-energy house (case-study 1) versus a conventional energy-intensive house (case-study 2) shows that a 'systems of practice' (2012) approach is needed for housing practices to transition towards less energy-intensive configurations. The analysis demonstrated inadequacies of the existing techno-determinist economic and efficiency models in housing to meet the required levels of low-energy housing demand. The paper further explored potential low-energy interventions using Spurling et al.'s (2013) practice-oriented framework through re-crafting and substituting housing practices and changing how they interlock.

The analysis shows that housing practices have direct and indirect implications on household practices, mediated through the house design. While the conventional case-study represents an energy-intensive model of unsustainable housing and household practices, the low-energy case-study represents a more sustainable variant; i.e. integration of more flexible, custom-tailored byelaws to meet minimum standards, better knowledge and skills of the practitioners, good communication between stakeholders and the availability of low-carbon materials has led to 'good' household practices: e.g. changed meanings of comfort, more outdoor-based activities and collective practice-arrangements. Case-study 2 demonstrates that economically viable, low-energy systems of interlinking 'good' housing and household practices are not only possible, but already exist and can inform alternative models for low-energy housing transitions.

The changing ideals of home are important in the context of Lahore since middle-class housing is driven by the Western-inspired modernist perception of housing and consumption that can be inherently ill-suited to the climate as well as local cultural needs, such as notions privacy or gender. This can result in competing economic, social and cultural requirements, increasing energy-intensity of household practice-arrangements and raises questions about existing notions of 'good design' and 'ideal home' (e.g. Gram-Hanssen and Darby, 2018). It also challenges the rhetoric of sustainability transitions from purely focusing on efficiency to include 'opportunities for social innovation' (Macrorie et al., 2015, p. 103) as exemplified by case-study2. In the case of Lahore, this could mean revival of craftsmanship (e.g. Mumtaz, 1985) or supporting self-build (e.g. see Low-Cost Housing Research Programme, Karachi in Till and Schneider, 2012).

The analysis shows that investigating low-energy transitions in housing and household practices through a practice-oriented framework is useful for conceptualising interventions in design and use and exposing the connections between "good" and "bad" housing and household practices, as mediated through the house design. Practice theory reveals that housing in Lahore, and its' increasing energy demand, is a result of a complex system of practices that include housing infrastructure and

institutional regulations, skills and knowledge of the practitioners, material supply chains as well as socio-economic market demand (as shown in Figure 31 and 32). The application of this intervention framework in other contexts and case-studies can similarly be used to reveal the various systems of housing and household practices and where the agency lies for low-energy transitions. Whilst very similar trends in housing can be found in other countries in South Asia in the emerging middle-class (e.g. see Hansen et al., 2016; Wilhite, 2008), the framework has wider applicability to uncover other types of stakeholders and their agentive role in low-energy housing transitions in the wider Global South (e.g. investigating the links between South Africa's housing practices and the banking sector —shown to have agentive power in middle-class housing affordability in Lemanski, (2017) and also in the West (e.g. see Macrorie et al., 2015) for an investigation of systems of housing practices in the UK). A system's framework helps reveal how domestic energy demand is contingent on the specific interlocking housing and household practices, where architects as designers and homeowners as end-users have limited agency for change. This contests behaviour change models that rely on individuals to make the 'right' decisions and negates the perceived benefits of housing and energy policies that focus on purely technological solutions or innovations. While most energy studies focus on establishing links between the house and household practices, our study suggests that this link may be less important than the link between housing and household practices for low-energy housing transitions.

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References

Ahmed, M., 2016. Contemporary built form in Pakistan: an analysis of residences and urban areas of Lahore. J. Res. Archit. Plan. 20, 21.

Anderson, K., Bows, A., 2011. Beyond "dangerous" climate change: emission scenarios for a new world. Philos. Trans. R. Soc. Math. Phys. Eng. Sci. 369, 20–44. https://doi.org/10.1098/rsta.2010.0290

Anis-ur-Rahmaan, Anis, B., 2009. Dynamics of gated communities, their impact and challenges for sustainable development: A case study of Lahore, Pakistan. Int. J. Archit. Res. ArchNet-IJAR 3, 57–70.

Awan, N., Schneider, T., Till, J., 2011. Spatial agency: other ways of doing architecture. Routledge, Abingdon, Oxon [England]; New York, NY.

Bajwa, I.U., Ahmad, I., Khan, Z., 2008. Urban Housing Development in Pakistan; A Case Study Of Lahore Metropolitan Area.

Bajwa, K.W. (Ed.), 2013. Urban Pakistan: frames for imagining and reading urbanism, Oxford in Pakistan readings in sociology and social anthropology. Oxford University Press, Karachi, Pakistan.

Becker, R., Foliente, G., 2005. Performance Based International State of the Art (PeBBu 2nd International SotA Report EUR 21989 No. CIBdf), Performance Based Building Thematic Network 2001-2005. Performance Based Building Thematic Network 2001-2005, Rotterdam.

Bhan, G., 2017. From the basti to the 'house': Socio-spatial readings of housing policy in India. Curr. Sociol. 65, 587–602. https://doi.org/10.1177/0011392117697465

Bourdieu, P., 1984. Distinction: A Social Critique of the Judgement of Taste, Translated by Richard Nice. Harvard University Press, Cambridge, Massachusetts.

Bourdieu, P., 1970. The Berber house or the world reversed. Inf. Int. Soc. Sci. Counc. 9, 151–170.

Browne, A.L., 2016. Histories, Trajectories and Patterns of Cleanliness, Energy and Water Consumption: Reflections on China. DEMAND Centre Conference Lancaster.

Chan, J., 2015. Moral Agency in Architecture? The Dialectics of Spatializing Morality and Moralizing Spaces, in: Muller, A.-L., Reichmann, W. (Eds.), Architecture, Materiality and Society: Connecting Sociology of Architecture with Science and Technology Studies. Palgrave Macmillan, Houndmills, Basingstoke, Hampshire, pp. 198–214.

Dutton, T.A., Mann, L.H. (Eds.), 1996. Reconstructing Architecture: Critical Discourses and Social Practices, Pedagogy and Cultural Practice. University of Minnesota Press, Minneapolis London.

EIA, 2016. International Energy Outlook 2016. U.S. Energy Information Administration (EIA), Washington, D.C.

Fallan, K., 2008. Architecture in action: Traveling with actor-network theory in the land of architectural research. Archit. Theory Rev. 13, 80–96. https://doi.org/10.1080/13264820801918306

Farooqui, R.U., Ahmed, S.M., Lodi, S.H., 2008. Assessment of Pakistani Construction Industry – Current Performance and the Way Forward. J. Adv. Perform. Inf. Value, CIBW117 1.

FBR, 2018. Finance Act, 2018 - Explanation of important amendments made in the Income Tax Ordinance, 2001 (Income Tax circulars No. C.No.4(69)1T-Budgetl2018-109192-R). Federal Board of Revenue, Government of Pakistan, Islamabad.

Flyvbjerg, B., 2006. Five Misunderstandings About Case-Study Research. Qual. Inq. 12, 219–245. https://doi.org/10.1177/1077800405284363

Foliente, G.C., 2000. Developments in performance-based building codes and standards. For. Prod. J. Madison 50, 12–21.

Foulds, C., Powell, J., Seyfang, G., 2013. Investigating the performance of everyday domestic practices using building monitoring. Build. Res. Inf. 41, 622–636. https://doi.org/10.1080/09613218.2013.823537

Gans, H.J., 2002. The sociology of space: A use-centered view. City Community 1, 329–339. https://doi.org/10.1111/1540-6040.00027

Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Res. Policy, NELSON + WINTER + 20 31, 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

Ghani, J.A., 2014. The emerging middle class in Pakistan: how it consumes, earns, and saves, in: International Conference on Marketing. Presented at the IBAICM 2014, Institute of Business Administration (IBA) Karachi, Karachi.

Gieryn, T.F., 2002. What buildings do. Theory Soc. 31, 35–74.

Graaf, R. de, 2017. Four walls and a roof: The complex nature of a simple profession. Harvard University Press, Cambridge, Massachusetts.

Gram-Hanssen, K., 2011. Understanding change and continuity in residential energy consumption. J. Consum. Cult. 11, 61–78. https://doi.org/10.1177/1469540510391725

Gram-Hanssen, K., 2008. Consuming technologies – developing routines. J. Clean. Prod. 16, 1181–1189. https://doi.org/10.1016/j.jclepro.2007.08.006

Gram-Hanssen, K., Darby, S.J., 2018. "Home is where the smart is"? Evaluating smart home research and approaches against the concept of home. Energy Res. Soc. Sci. 37, 94–101. https://doi.org/10.1016/j.erss.2017.09.037

Grubb, M.J., 1990. Communication Energy efficiency and economic fallacies. Energy Policy 18, 783–785. https://doi.org/10.1016/0301-4215(90)90031-X

Guy, S., Shove, E., 2000. A sociology of energy, buildings, and the environment: constructing knowledge, designing practice. Routledge, London; New York.

Halkier, B., Jensen, I., 2011. Doing 'healthier' food in everyday life? A qualitative study of how Pakistani Danes handle nutritional communication. Crit. Public Health 21, 471–483. https://doi.org/10.1080/09581596.2011.594873

Hand, M., Shove, E., Southerton, D., 2005. Explaining showering: a discussion of the material, conventional, and temporal dimensions of practice. Sociol. Res. Online 10. https://doi.org/10.5153/sro.1100

Hansen, A., Nielsen, K.B., Wilhite, H., 2016. Staying Cool, Looking Good, Moving Around: Consumption, Sustainability and the 'Rise of the South.' Forum Dev. Stud. 43, 5–25. https://doi.org/10.1080/08039410.2015.1134640

Haque, M.S., 2000. Privatization in Developing Countries: Formal Causes, Critical Reasons, and Adverse Impacts, in: Farazmand, A. (Ed.), Privatization or Public Enterprise Reform?, Privatization or Reform: Public Enterprise Management in Transition. Greenwood Press, Westport, Conn., pp. 217–238.

Hatch, C.R., 1984. The Scope of social architecture. Van Nostrand Reinhold, New York.

Higginson, S., Thomson, M., Bhamra, T., 2014. "For the times they are a-changin": the impact of shifting energy-use practices in time and space. Local Environ. 19, 520–538. https://doi.org/10.1080/13549839.2013.802459

Horta, A., Wilhite, H., Schmidt, L., Bartiaux, F., 2014. Socio-Technical and Cultural Approaches to Energy Consumption: An Introduction. Nat. Cult. 9. https://doi.org/10.3167/nc.2014.090201

Imrie, R., Street, E., 2014. Autonomy and the socialisation of architects. J. Archit. 19, 723–739. https://doi.org/10.1080/13602365.2014.967271

Janda, K.B., 2011. Buildings don't use energy: people do. Archit. Sci. Rev. 54, 15–22. https://doi.org/10.3763/asre.2009.0050

Janda, K.B., Parag, Y., 2013. A middle-out approach for improving energy performance in buildings. Build. Res. Inf. 41, 39–50. https://doi.org/10.1080/09613218.2013.743396

Jensen, C.L., Wade, F., Pettersen, I.N., Kuijer, L., 2014. How do material objects transcend the boundaries between professional and domestic practices?, in: Foulds, C., Jensen, C.L. (Eds.), Practices, the Built Environment and Sustainability – A Thinking Note Collection. GSI, DIST, BSA CCSG., Cambridge, Copenhagen, London.

Khalid, R., Sunikka-Blank, M., 2018. Evolving houses, demanding practices: A case of rising electricity consumption of the middle class in Pakistan. Build. Environ. 143, 293–305. https://doi.org/10.1016/j.buildenv.2018.07.010

Khalid, R., Sunikka-Blank, M., 2017. Homely social practices, uncanny electricity demands: Class, culture and material dynamics in Pakistan. Energy Res. Soc. Sci. 34, 122–131. https://doi.org/10.1016/j.erss.2017.06.038

Khan, M., 1994. Cultural Transfers: The Repossession of Architectural Form. Environ. Des. J. Islam. Environ. Des. Res. Cent. 1-2 84–103.

Khazzoom, J.D., 1980. Economic Implications of Mandated Efficiency in Standards for Household Appliances. Energy J. 1, 21–40.

King, A., 1990. Architecture, Capital and the Globalization of Culture: Theory Cult. Soc. 7, 397–411. https://doi.org/10.1177/026327690007002023

King, A.D., 1984. The Bungalow: The Production of a Global Culture. Routledge & Kegan Paul, London.

Knox, P.L., 1987. The Social Production of the Built Environment Architects, Architecture and the Post-Modern City. Prog. Hum. Geogr. 11, 354–377. https://doi.org/10.1177/030913258701100303

Kuijer, L., Watson, M., 2017. 'That's when we started using the living room': Lessons from a local history of domestic heating in the United Kingdom. Energy Res. Soc. Sci. 28, 77–85. https://doi.org/10.1016/j.erss.2017.04.010

Latour, B., 2005. Reassembling the social: an introduction to actor-network-theory, Clarendon lectures in management studies. Oxford University Press, Oxford ; New York.

Latour, B., Yaneva, A., 2008. Give me a gun and I will make all buildings move: An ANT's view of architecture. Explor. Archit. Teach. Des. Res. 80–89.

LDA, 2004. Integrated Master Plan of Lahore (IMPL)-2021 (Volume 1: Existing Scenario). Prepared by NESPAK for Lahore Development Authority (LDA), Lahore.

Lemanski, C., 2017. Citizens in the middle class: The interstitial policy spaces of South Africa's housing gap. Geoforum 79, 101–110. https://doi.org/10.1016/j.geoforum.2016.12.011

Loorbach, D., Frantzeskaki, N., Avelino, F., 2017. Sustainability Transitions Research: Transforming Science and Practice for Societal Change. Annu. Rev. Environ. Resour. 42, 599–626. https://doi.org/10.1146/annurev-environ-102014-021340

Lorne, C., 2017. Spatial agency and practising architecture beyond buildings. Soc. Cult. Geogr. 18, 268–287. https://doi.org/10.1080/14649365.2016.1174282

Macrorie, R.M., Foulds, C., Hargreaves, T., 2015. Governing and governed by practices: Exploring interventions in low-carbon housing policy and practice, in: Strengers, Y., Maller, C. (Eds.), Social Practices, Intervention and Sustainability: Beyond Behaviour Change, Routledge Studies in Sustainability. Routledge, London New York, pp. 95–111.

Maller, C., Horne, R., Dalton, T., 2012. Green Renovations: Intersections of Daily Routines, Housing Aspirations and Narratives of Environmental Sustainability. Hous. Theory Soc. 29, 255–275. https://doi.org/10.1080/14036096.2011.606332

McMeekin, A., Southerton, D., 2012. Sustainability transitions and final consumption: practices and socio-technical systems. Technol. Anal. Strateg. Manag. 24, 345–361. https://doi.org/10.1080/09537325.2012.663960

McNeill, D., 2006. Globalization and the ethics of architectural design. City 10, 49–58. https://doi.org/10.1080/13604810600594639

MoHW, 2001. National Housing Policy 2001. Ministry of Housing & Works, Government of Pakistan, Islamabad.

Müller, A.-L., Reichmann, W. (Eds.), 2015. Architecture, materiality and society: connecting sociology of architecture with science and technology studies. Palgrave Macmillan, Basingstoke.

Mumtaz, K.K., 1985. A case for indigenous development, in: Powell, R. (Ed.), Regionalism in Architecture, Exploring Architecture in Islamic Cultures 2. Published for the Aga Khan Award for Architecture, 1985 by Concept Media, Singapore, pp. 55–57.

National Housing Policy Pakistan, 2001. National Housing Policy. Ministry of Housing & Works, Government of Pakistan, Islamabad.

PBS, 2015. Household Integrated Economic Survey (HIES) 2013-14. Pakistan Bureau of Statistics, Government of Pakistan, Islamabad.

Powell, R. (Ed.), 1985. Regionalism in Architecture, Exploring Architecture in Islamic Cultures 2. Published for the Aga Khan Award for Architecture, 1985 by Concept Media, Singapore.

Priemus, H., 2007. System Innovation in Spatial Development: Current Dutch Approaches. Eur. Plan. Stud. 15, 992–1006. https://doi.org/10.1080/09654310701448147

Qadeer, M., 2006. Pakistan: Social and cultural transformations in a Muslim nation. Routledge, Abingdon, Oxon. https://doi.org/10.4324/9780203099681

Redström, J., 2006. Towards user design? On the shift from object to user as the subject of design. Des. Stud. 27, 123–139. https://doi.org/10.1016/j.destud.2005.06.001

Rinkinen, J., Jalas, M., 2017. Moving home: houses, new occupants and the formation of heating practices. Build. Res. Inf. 45, 293–302. https://doi.org/10.1080/09613218.2016.1143299

Rinkinen, J., Jalas, M., Shove, E., 2015. Object Relations in Accounts of Everyday Life. Sociology 49, 870–885. https://doi.org/10.1177/0038038515577910

Ropke, I., Gram-Hanssen, K., Jensen, J.O., 2007. Households' ICT use in an energy perspective, in: The Good, the Bad and the Unexpected: The User and the Future of Information and Communication Technologies. Presented at the COST Action 298, Russian Federation, Moscow, pp. 595–611.

Sahakian, M., 2014. Keeping Cool in Southeast Asia: Energy Consumption and Urban Air-Conditioning. Palgrave Macmillan UK.

Saunders, H.D., 2000. A view from the macro side: rebound, backfire, and Khazzoom-Brookes. Energy Policy 11.

Scott, K., Bakker, C., Quist, J., 2012. Designing change by living change. Des. Stud. 33, 279–297. https://doi.org/10.1016/j.destud.2011.08.002

Sharp, L., 2009. Foreword, in: Green Building Through Integrated Design, McGraw-Hill's GreenSource Series. The McGraw-Hill Companies, NewYork, pp. xi–xiv. https://doi.org/10.1036/0071546014

Shen, W., Hao, Q., Mak, H., Neelamkavil, J., Xie, H., Dickinson, J., Thomas, R., Pardasani, A., Xue, H., 2010. Systems integration and collaboration in architecture, engineering, construction, and facilities management: A review. Adv. Eng. Inform. 24, 196–207. https://doi.org/10.1016/j.aei.2009.09.001

Shove, E., 2017. What is wrong with energy efficiency? Build. Res. Inf. 1–11. https://doi.org/10.1080/09613218.2017.1361746

Shove, E., 2010. Beyond the ABC: Climate Change Policy and Theories of Social Change. Environ. Plan. A 42, 1273–1285. https://doi.org/10.1068/a42282

Shove, E., Pantzar, M., Watson, M., 2012. The Dynamics of Social Practice: Everyday Life and how it Changes. SAGE Publications, London.

Shove, E., Watson, M., Hand, M., Ingram, J., 2007. The Design of Everyday Life. Berg Publishers, New York, NY.

Smits, M., 2011. Progressive contextualisation of energy practices and trajectories: A case study in Thailand. Rural Soc. 20, 280–293. https://doi.org/10.5172/rsj.20.3.280

Spurling, N., McMeekin, A., 2015. Interventions in practices: Sustainable mobility policies in England, in: Strengers, Y., Maller, C. (Eds.), Social Practices, Intervention and Sustainability: Beyond Behaviour Change, Routledge Studies in Sustainability. Routledge, London New York, pp. 95–111.

Spurling, N., McMeekin, A., Shove, E., Southerton, D., Welch, D., 2013. Interventions in practice: re-framing policy approaches to consumer behaviour (Sustainable Practices Research Group). Manchester.

Strengers, Y., Maller, C., 2015. Social Practices, Intervention and Sustainability: Beyond behaviour change. Routledge, London, New York.

Till, J., Schneider, T., 2012. Invisible Agency. Archit. Des. 82, 38–43. https://doi.org/10.1002/ad.1426

Tiwari, P., Rao, J., 2016. Housing markets and housing policies in India, in: ADB Institute, ADBI Working Paper Series.

UNDP, 2013. The rise of the South: Human Progress in a Diverse World (Human Development Report). United Nations Development Programme, New York.

Watson, M., 2012. How theories of practice can inform transition to a decarbonised transport system. J. Transp. Geogr. 24, 488–496. https://doi.org/10.1016/j.jtrangeo.2012.04.002

Wilhite, H., 2008. Consumption and the transformation of everyday life: a view from South India. Palgrave Macmillan, Hampshire.

Wilhite, H., Lutzenhiser, L., 1999. Social Loading and Sustainable Consumption. ACR North Am. Adv. NA-26.

World Bank, 2017. Pakistan - Housing Finance Project. World Bank Group, Washington, D.C.

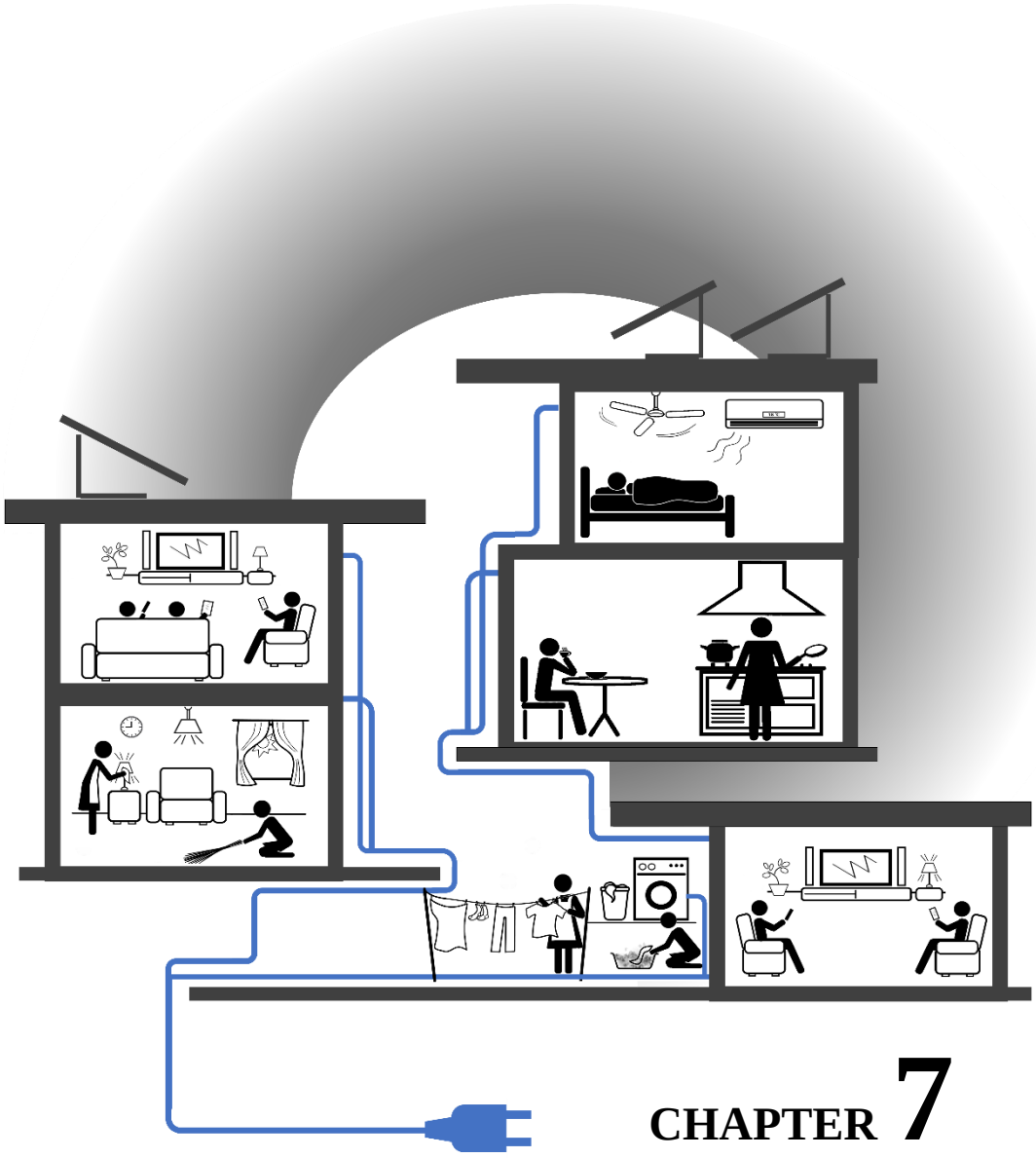
Yaneva, A., 2009. Making the Social Hold: Towards an Actor-Network Theory of Design. Des. Cult. 1, 273–288. https://doi.org/10.1080/17547075.2009.11643291

Yin, R.K., 2014. Case Study Research: Design and Methods, 5th ed. SAGE Publications, California, US.

Yudelson, J., 2009. Green Building Through Integrated Design, eBook. ed, McGraw-Hill's GreenSource series. The McGraw-Hill Companies, NewYork. https://doi.org/10.1036/0071546014

Yudelson, J., Meyer, U., 2013. The world's greenest buildings: promise versus performance in sustainable design. Routledge/Taylor & Francis Group, New York.

Zhang, L., 2010. In Search of Paradise: Middle-class Living in a Chinese Metropolis, 1st ed. Cornell University Press.



CHAPTER 7

7. Conclusions

In order to improve domestic energy demand management, there is first a critical need to understand what this demand is for, how it becomes part of the daily routines and practices of homeowners, and how it gets mediated by the house design and wider systems of housing practices. This study of household and housing practices aimed to make 'visible' the structures and patterns of demand, the interconnections between different practices at varying scales, the various change-agents involved and potential pathways for sustainability interventions in house design and use. This dissertation set out to fill the gap in studies of domestic energy consumption in the Global South from a socio-technical perspective. It built an understanding of the social and material constructs of domestic energy demand that shape middle-class houses in Lahore, Pakistan. Through an interdisciplinary approach, combining practice theories from the social sciences with ideologies of spatial agency in design from architecture, the thesis aimed to develop a comprehensive understanding of household and housing practices in Pakistan with the objective of exploring low-energy sustainability interventions in house design and use.

This chapter offers concluding remarks and summarises the main findings in each empirical chapter. It goes on to highlight some of the main theoretical and methodological contributions of the dissertation and concludes with the research and policy implications.

7.1. Summary of main findings

This dissertation set out to achieve two main objectives: developing a comprehensive understanding of middle-class household energy demand and practices in Lahore, Pakistan; and understanding how these fit within the wider system of housing practices to inform low-energy interventions in house design and use. The main findings of the dissertation are summarised in terms of the six research questions put forth in the four empirical chapters;

1. How do the material arrangements adapt to and shape everyday household practices and the resulting electricity consumption?
2. What role do the socio-cultural dynamics play in structuring homeowners' daily practices and the resulting electricity consumption?

Ch. 3 (Paper 1)

The findings of Chapter 3 (Paper 1), based on 10 middle-class case-study houses in Lahore, reveal the complex, interconnected nature of electricity-use in everyday household practices related to comfort, cleanliness, cooking, lighting, ICT and entertainment that are shaped by the material and socio-cultural arrangements within households and within the wider community. It shows that materiality in its varying forms (including the electricity provision system, backup power equipment, the house design and electrical appliances) plays an intrinsic role in shaping, and in turn being shaped by, everyday household practices. This includes the energy infrastructure with its intermittent electricity supply system and ways to overcome it that make electricity tangible for households and influence spatiotemporal arrangements of domestic practices. The results show how Western-inspired house designs with open plan layouts that are becoming increasingly popular among middle classes in Pakistan can present conflicts with homeowners' cultural needs for privacy and segregation, as well as the use of individual electrical appliances like air-conditioners.

The study in Paper 1 shows how the socio-cultural structures of society play an intrinsic part in shaping domestic electricity consumption both explicitly and implicitly; from wider social and cultural expectations and acceptance of practices within the neighbourhood community, such as portraying the right social image through the exterior front elevation and drawing décor, as well as having a socially acceptable number of refrigerators in the house; to religious meanings and ideologies that define the spatiotemporal arrangements of everyday life, such as the need for private spaces for female chores or having a different temporal routine on Fridays; to joint family structures, age disparities and gender roles. The research reveals the gendered nature of energy use, where for example, decisions related to energy systems, billing and appliance purchase are made by men while the domestic use of electricity in various household practices is largely the responsibility of females, who can thus play a key role in domestic energy management in Pakistan. The findings demonstrate how the understanding of electricity-use through 'homely' household practices helps unfold the otherwise 'uncanny' electricity demand in houses. Though confined to a single case, the study thus

addresses the gap in socio-technical energy-use studies in Pakistan and has broader methodological applicability and implications for countries in the Global South.

3. How have the socio-material structures of household electricity demand evolved in middle-class houses in Lahore and what lessons can be learned from this historical analysis?	Ch.4 (Paper 2)

The analyses presented in Chapter 4 (Paper 2) shows the historical evolution of household practices and house spatial layouts over the last century in Lahore and how current practice-arrangements in middle-class households, as analysed in detail in Chapter 3 (Paper 1), have emerged through a longitudinal process of coevolution, where both the social and material structures have mutually shaped the edifice of middle-class housing and subsequent electricity demands. The analysis of archival documents, building regulations, house plans, case-studies and oral history narratives revealed three key processes of change in household practice-arrangements in middle class households in Pakistan; a shift from more outdoor to indoor activities, shift from an inward to an outward oriented design, and the spatial dispersion of practices. The paper shows that culturally ill-suited and diminishing outdoor spaces gradually resulted in practices moving from outdoors to indoors. Consequently, indoor spaces were adapted to accommodate these practices, leading to increased electricity consumption, for example in mechanical ventilation and cooling through air-conditioning. While the impact of technology (air-conditioning and television in particular) has been important, the results show that assigning it complete agentive power is misleading, as this overlooks the important links between material structures and the social institutions, cultural needs and collective norms and values; for instance, the need for privacy in outdoor spaces for female use and planning regulations that allow mixed-use housing communities that can perhaps reduce mobility demands.

The study in Paper 2 shows that changes in spatial layouts are a result of complex transformations including colonisation, Westernisation and consumerism but also ongoing traditional values and norms. The persistence of certain cultural imaginaries of privacy, gender segregation and joint family systems when juxtaposed with modern spatial configurations, give rise to conflicts in practices; for example, open-plan houses do not provide adequate privacy indoors nor link to outdoors. The historical analysis of household practice-arrangements provided valuable insight into how and why domestic electricity consumption continues to increase in countries in the Global South, despite improved efficiency of appliances and building fabric.

4. How does household electricity consumption relate to practice temporalities and materiality in different cultural contexts and what are the implications for energy demand management? — Ch. 5 (Paper 3)

The cross-cultural comparative analysis undertaken in Chapter 5 (Paper 3) helps to uncover the links between micro-level mundane household practices and the broader macro-level socio-material infrastructural and institutional systems. Comparison of the 10 middle-class households and their electricity consumption practices from Chapter 3 (Paper 1) with a similar study of 13 middle-class households from Denmark helps to identify variety in the performance of similar practices in two significantly different cultural contexts. It also reveals that homeowners' practices, both in the Pakistani and Danish cases, are influenced by the varying electricity provision systems and, at the same time, highly contextualised and embedded within the wider socio-material and cultural settings like joint family structures, 'servant culture' and collective norms. These influence the type of appliances used at home, responsibility allocation for practice performance and the flexibility in the spatiotemporal arrangement of household practices. These have implications for the electricity demand management that can be expected and, consequently, the solutions proposed in smart-grid transitions as well as in the possible cross-cultural transfer of smart technology and demand response strategies. Hence, different demand management strategies are required for achieving energy savings, such as promoting automated time-control in dual-income households in Denmark and encouraging more service-driven practices, like outsourcing laundering facilities in Pakistan.

The study adds to the gap in literature on cross-cultural comparative studies, specifically between countries from the Global North and the Global South. The cross-cultural study illustrates how deeper and more direct connections are being forged between the changing electricity provision systems and daily household practices that have implications for effective demand management. The study shows that technology is just one of many co-constitutive elements of practices, including know-how, knowledge and engagements, which differ and interlink in different ways in varying contexts. This has consequences for the effective transfer of technology and energy demand management strategies from one country to another or from one context to another. For example, replacing older semi-automatic washing machines with advanced, more efficient models that offer automated time control for demand flexibility may not work in some Pakistani households because of existing practices of labour division between homeowners and housemaids. Hence, the effective 'diffusion' of smart infrastructure that is predominantly developed in the Global North to countries like Pakistan in the Global South would require a reframing of the existing electricity consuming practices.

5. How does the house design mediate electricity consumption in household practices? 6. How can interventions in housing practices lead to less-energy intensive household practice-arrangements?	Ch. 6 (Paper 4)

Taking practice as a unit of analysis in Chapter 3, 4 and 5, Chapter 6 (Paper 4) moves on to explore practice as a unit of intervention. The findings of Chapter 6 (Paper 4) show that housing (design) practices have direct and indirect implications on household (use) practices, mediated through the house design. The analysis of two critical case-study houses as examples of variation in design reveals that the house design and household practices together form specific bundles of practice-arrangements that prefigure electricity consumption pathways (such as promoting more indoor versus outdoor space use) and consequently determine domestic energy demand. It further uses Spurling et al.'s (2013) practice-based intervention framework to explore how housing and household practices can be recrafted, substituted and changes made to how they interlock for low-energy transitions.

Based on semi-structured interviews with architects, planners and builders/developers, the study shows that housing practices in Lahore, though reliant on technologies and infrastructure, also depend on the skill-set and competences of the practitioners as well as the meanings associated with 'ideal' housing, 'good' design and appropriate household practices. Whilst improvement in construction techniques and building materials can improve the efficiency of house building, it may not lead to interventions in household practices if it does not take account of the other constitutive elements and change-agents that shape housing practices, such as established norms for inherently inefficient bungalow typology.

"Good" housing practices such as integration of more flexible, performance-based building regulations to meet minimum standards, better knowledge and skills of practitioners, good communication between stakeholders and the availability of low-carbon material supply chains can, through mediation of the house design, can facilitate "good" household practices, such as changed meanings of comfort, more outdoor-based activities and collective practice-arrangements. Similarly, "bad" household practices, such as more indoor-based activities with greater reliance on mechanical modes of comfort, can be hindered through disrupting their reproduction and prefiguration in the system of housing practices; for example, by challenging existing building regulations that continue to uphold bungalow-style configurations. The study adds to practice theory research by emphasising the importance of understanding not just the household practices of end-users, but also the housing practices of professional experts for improved domestic energy demand. The study is thus relevant for practice-based research in countries in the Global South and also in Western countries.

7.2. Research contribution

The following sections summarise the empirical, theoretical and methodological contributions of the thesis.

7.2.1. Empirical Contribution

The thesis contributes to the limited literature and empirical research that looks at how and why the design and use of middle-class houses has become more energy-intensive over time in the Global South, taking Pakistan as a case study, and therefore contributing to the under-researched area of energy demand in developing countries. The empirical investigation, based on practice-based approach, document analysis, case-studies and stakeholder interviews, shows that domestic energy demand is embedded in the social and material structures that constitute the middle-class in Lahore. By doing so, the dissertation highlights the inadequacies of existing techno-determinist and economic rationale models in building energy policies. By a study of middle-class housing typologies, it provides new evidence of how socio-material transitions that have taken place over the last century in housing in Lahore, giving rise to unprecedented, unintended and unsustainable household practice-arrangements.

The thesis reinforces the established interconnections between building energy consumption and household practices but goes on further to explore the links between household and housing practices to show that domestic energy demand is interlocked in the wider system of structural housing practices in which individuals like architects and homeowners have limited agency for change.

The research proposes low-energy interventions in household and housing practices that can lead to low-energy transitions in middle-class housing in Lahore. For instance, interventions in housing practices such as substituting building regulations that continue to prefigure unsustainable practices; reframing building codes that advocate 'ethics of sustainability' into conventional understandings of 'ethics of responsibility'; integration of more flexible byelaws to meet minimum standards; improving the knowledge and skills of practitioners; creating channels of dialogue between the designers/developers and end-users; and ensuring the availability of low-energy, low-carbon material supply chains. Such housing interventions can support more sustainable household practices, such as changed meanings of comfort, more outdoor-based activities and collective practice-arrangements.

7.2.2. Theoretical Contribution

This dissertation is the first application of SPT in the context of domestic energy demand in Pakistan and it adds to the limited research on energy demand as an outcome of social practices in developing countries in the Global South. The research contributes to the theoretical implications of practice-based research in two ways; first, the current conceptual understandings of practices and potential

low-energy interventions, based on studies of consumption in the West, cannot be applied in the socially-differentiated context of a developing country where the performances of practices differ due to socio-cultural aspects like joint family structures and notions of privacy.

Second, while most energy consumption studies using theories of practice build on Schatzki (1996; 2001) and Reckwitz (2002a), adopting their lack of emphasis on the socio-economic dimension, the application of practice theories in a non-Western context in this thesis has helped to highlight how class and capital can have significant impact on practice formations. The study shows how different forms of capital, such as social, cultural and even religious capital, can have varying amounts of significance in different contexts and can therefore result in the emergence, persistence and change of socially differentiated practices. This subsequently has an impact on consumption and any potential sustainability intervention. Hence, the study suggests that Bourdieu's (1984, 1986) notions of class and capital, rooted in socio-economic descriptors, could help to understand better the social differentiation of practices, preferences and norms in different socio-economic settings and need to be (re)introduced to contemporary practice theory. The (re)inclusion of Bourdieu's concept of social distinction and capital is also advocated by McMeekin and Southerton (2012), Galvin and Gubernat (2016) and Galvin and Sunikka-Blank (2016).

The dissertation also contributes to the debate on the relations of materiality with practices in accounts of everyday life and energy demands. The position of materiality within practices is contested, with questions surrounding the degree of agentive capacity of materials in practices, the compatibility of material relations with practices and the changing status/roles of materiality in practice (e.g. Rinkinen et al., 2015; Shove, 2016). While Shove and Pantzar's (2005) framework that depicts materiality as a constituent element of practices provides a useful heuristic to understand household electricity consumption (in Chapter 3), Sckatzki's (2010, 2011) conceptualisation of social order as a plenum of practices and material arrangement bundles is found better suited to the longitudinal analysis of mutually evolving house spatial layouts and household practices (Chapter 4). Specifically, Schatzki's concepts of historicity and prefiguration- one form of relation between practices and material arrangements- proves critical in determining key themes. However, reliance on practice theories alone is found insufficient in forming links between micro-level household practices and macro-scale practices of various housing professionals and exploring subsequent interventions (Chapter 6). In this case, combining practice theories with the STS (more specifically ANT) concept of architecture (one form of materiality) as a mediator proves invaluable in forming links between seemingly divergent practices at varying scales. This also helps overcome the pitfalls in STS theories (e.g. ANT), which often assign non-human (material) factors equal agency as humans. Alternatively, reliance on architectural design concepts alone proves insufficient, as they often neglect the social dimension and take on a spatial determinist approach. Therefore, by combining Schatzki's conceptualisation of social order as a plenum of practice-material arrangement bundles with concepts of spatial agency in design

from the field of Architecture and using the concept of architecture as mediator from STS, the dissertation presents a novel interdisciplinary approach to understanding the socio-material constructs of domestic energy demand. The dissertation demonstrates the overlapping and intersecting nature of the material and social structures and how the different forms of materiality (e.g. individual appliances, spaces and the intermittent electricity provision system) shape and, in turn, are shaped by everyday household practices (Chapter 3, Paper 1). It also reveals the mutual dependency and coevolution of spatial arrangements in houses and household practices (Chapter 4, Paper 2) and how design can mediate "good" (or "bad") household practices and resulting electricity demands (Chapter 6, Paper 4).

Unlike most practice-based empirical studies that focus on the household practices of homeowners to study domestic energy consumption, this dissertation broadens the scale of study to the wider institutional and infrastructural systems that define housing practices. By doing so, it provides evidence to refute critiques of practice theories as suited only to small-scale or micro-meso level analysis of social order and its lack of accountability for macro-level transitions (Hui et al., 2017). By zooming in to the household level practices and consequent electricity consumption and then zooming out to link them with the housing practices of, for example, practitioners, that define the housing system in Lahore, this dissertation reinforces the view that macro-scale phenomena are constituted by and emerge through the aggregation of interrelated practices at the micro-meso level (Nicolini, 2017).

Further, by applying practice theory as a unit of intervention in design and use, the dissertation expands the theoretical implications of practice theory, which is well known in its use as a tool of analysis in the sociology of consumption, but less applied in the field of sustainability transitions for governing change.

7.2.3. Methodological Contribution

Statistics show that only approx. 20% of energy related research takes a Social Sciences and Humanities (SSH) approach (Sovacool, 2014) and from the range of methodologies used, only 12% apply an interpretivist approach to energy and building research (Schweber and Leiringer, 2012). This dissertation responds to this gap by employing an interpretivist research design and using a socio-technical approach to investigate domestic energy demand.

The thesis contributes to the application of mixed methods in an SPT approach to energy research, specifically in the context of developing countries in the Global South. It combines qualitative interviews and observation with quantitative data: case-study houses, archival documents on house plans and building regulations, photographic evidence, temp & humidity data monitoring (Appendix

9) and time-use diaries[29] (Appendix 8). By doing so, the dissertation helps to advance the boundaries of methodological frameworks and empirical methods applied in practice theory (Halkier and Jensen, 2011a; Jonas et al., 2017) that has been criticised for its weakness to explore causalities or offer solutions (Galvin and Sunikka-Blank, 2016). Using a combination of methods to collect empirical data for practice-based research helps to overcome the limitations of individual methods, expand the interpretation of the data, substantiate the analysis and triangulate findings to provide a more comprehensive and enriched picture of the socio-material patterns of domestic energy demand.

7.3. Implications for policy and research

Whilst building energy demand management is an extensive area of research, most of the existing literature either takes a technological determinist approach to energy efficiency or focuses on economic rationale models and psychological behaviour change. This dissertation builds on an interdisciplinary, socio-technical approach that re-defines energy consumption as a consequence of social practices. Most energy policies in Pakistan, as in many other countries in the Global South focus on energy generation, specifically for rural areas or low-income development, to overcome the energy supply-demand gaps (e.g. MoHW, 2001; Salama and Al-Sumaiti, 2014; Tiwari and Rao, 2016). In the absence of building energy codes for the domestic sector and lack of mandatory energy efficiency labelling for appliances and equipment, energy demand in the domestic sector remains unchecked. The thesis suggests that policies in developing countries in the Global South need to focus more on demand management, specifically in middle-class urban areas. By doing so, the research suggests a number of policy and research implications. Whilst the empirical findings and recommendations in this study may not be generalisable to other contexts due to their specific socio-material framings, the theoretical knowledge contribution and the methodological framework design have wider applicability in different contexts and implications for academics and researchers as well as architects, planners and policymakers more broadly.

Implications for policy:

- In the limited action undertaken for demand reduction in developing countries, there exists a prevalence of the 'physical-technical-economic model' (PTEM) (Lutzenhiser, 2014), as seen in the agenda set forth in Pakistan by the National Energy Efficiency Conservation Authority (NEECA) and the Pakistan Green Building Council (PGBC). Whilst improvement in technological efficiency and building fabrics can cut down on some of this incremental consumption, the findings of this study show how it remains insufficient to meet the necessary demand reduction targets and climate change goals. With increasing levels of consumption

[29] Although these have not been used in the four empirical chapters (journal papers) in this thesis but form part of a conference paper, submitted to the ECEEE Summer Study 2019.

in the emerging middle-class in the Global South, **housing and energy policies need to move beyond techno-economic rationale models of efficiency and include energy-related Social Sciences and Humanities perspectives for much needed sufficiency** (e.g. Calwell, 2010; Thomas et al., 2015; Shove, 2017), **through interdisciplinary energy research**.

- **House planning and development policies need to work in tandem with energy policies, so as not to contradict each other**, as evident in middle-class housing in Pakistan, where narrow peripheral outdoor spaces mandated by the bungalow-style regulations continue to prefigure indoor space use while exclusive zoning promotes increased mobility and inhibits multifunctional space-use. Instead of focusing simply on economic rationale models or technological efficiency in materials and appliances, building energy demand policies should focus on reframing the house layout and spatial configurations as well as urban and town planning regulations that can lead to better integration of energy policies with the local housing policies.
- The wider system of housing practices has direct and indirect implications on household practices, mediated through the house design. This wider system results in interlocking housing and household practices with specific energy demands, where architects as designers and homeowners as end-users are left with limited agency for change. Drawing links between micro-level household practices and energy demand and the wider system of housing practices at the macro-scale can have greater policy impacts for demand reduction. **Hence, urban planning and development authorities need to draft housing policies and encourage measures, such as performance-based building regulations and inclusive community development, that can lead to improved household energy demand.**
- **Energy policy should consider the gendered nature of energy use in households**, which exists not only in developing countries like Pakistan, but also in Western countries (e.g. Tjørring, 2016). If women are the dominant users of electricity in various household chores and practices, then domestic demand management policies (e.g. time-shifting) need to consider their impact on women and also design strategies that specifically target women for reduced consumption while ensuring equity and well-being.

Implications for further research include:

- **Need for understanding the longitudinal dynamics of practice-arrangements and diversity of practices in different cultural contexts**. This can help recognise and prevent normalisation of standards for the 'perfect' home that gradually become embedded and engrained in social practices and institutional systems. The rising standards in contemporary middle-class household practice-arrangements in developing countries in the Global South are likely to prefigure higher demands for electricity through increased consumption and

specification of spaces, unquestioned reliance on electricity and neglected use of outdoor space.

- The cross-cultural comparative study (Paper 3) shows that **demand management and response strategies need to be developed with better understanding of the local socio-cultural and material setting** for achieving energy savings and load-shifting. This shows the need for research on the implications of the transfer of technology and/or demand management strategies from one context to another, given that technology is a constitutive part of practices.
- **Introducing practice theory to an architectural design audience can provide a fresh perspective on critical architecture and design issues and an alternative view to the spatial-determinist approach** (Gans, 2002; Lorne, 2017) often taken by designers and architects, highlighting the importance of 'the social' in architecture (e.g. see Hatch, 1984; Knox, 1987; McNeill, 2006; Lorne, 2017). Kuijer's (2013; 2014) study highlights the advantages of introducing a practice-based framework to a product design audience. Using practice-theory in design research can help re-frame questions regarding the need for space and ideas about building form and aesthetics. Chapter 6 (Paper 4) demonstrates the importance of dialogue between architects and homeowners in housing practices to overcome discrepancies in design and use. This can lead to improved household energy efficiency and sufficiency and can help overcome issues concerning building performance gaps and unexpected consumption through rebound effects.

7.4. Scope for further study

Whilst the research in this dissertation is based on a mixed-method approach, a detailed quantitative study of the electricity consumption in the case-study houses was beyond the scope of this study due to time and cost constraints and provides an important direction for future research. Although electricity bills were collected from the case-study homeowners in Chapter 3 and environmental data monitoring of the various house spaces was carried out for the case-studies in Chapter 6, it was not included in the final version of these papers[30]. Triangulation of qualitative data with quantitative energy measurements can result in a much richer understanding of energy consumption in household practices and provide opportunities for comparing more and less energy-intensive performances. It can further corroborate the responses from interviewees regarding the spatiotemporal arrangement of their practices as well as provide insight into normative understandings of consumption.

Future research is also advocated in the empirical design and testing, and theoretical conceptualisation of energy interventions for domestic energy demand management. In this, the concept of 'disruptions'

[30] See Appendix 9 for temperature and humidity data calculations of the two case-study houses in Chapter 6

can be further investigated. Reckwitz (2002a) contends that social change occurs in 'the 'breaking' and 'shifting' of structures… in everyday crises of routines' (2002a, p. 255). Trentmann (2009) plays with the idea of disruptions as 'constitutive features of lived normality' (2009, p.69) that influence elasticity in action and resilience in systems. He sheds light on the disruptions of everyday life to show how routines and practices are interspersed with disjunctures, that unravel and are braided back together through the inherent elasticity in everyday life. In this sense, disruption no longer implies defection, rather becomes the norm. Likewise, Rinkinen (2013) explores the embracing of disruptions through invoking dormant practices and/or elements or their innovative use in performing new practices. On a similar strand, Nichols (2014) looks at innovation in individual practices in response to restrictive systemic standards and/or structures as alternate 'social desire paths' inspired from landscape architecture. According to the author, such social desire paths can help identify underlying needs and values beyond prescribed rules of laws, policies and organisations and consequently improve formal structures. Hence, analysis of such disruptive moments or social desire paths can prove beneficial in understanding societal transformation and consequently in designing intervention policies.

Further, a combination of practice theories with STS approaches that account for socio-technical change, such as the Multi-level Perspective (MLP) (e.g. Geels, 2002, 2010) or literature on transition management (Kemp and Loorbach, 2006; Loorbach et al., 2017) can perhaps lead to improved governance of societal change and tackle the challenges of sustainability transitions at different scales. Some seminal work in this regard has been undertaken by Rauschmayer et al. (2015), who combine transition management approaches with practice theory and the more individualistic capability approach to develop a holistic knowledge base for sustainability transitions research. McMeekin and Southert (2012) examine the tensions and cross-overs between MLP and practice theory and identify advantages of combining the two; for example, the importance of considering systematic processes of both production and final consumption for sustainability transitions. Hargreaves et al (2013) use two empirical case-studies to exemplify the benefits of complementing MLP with practice theory for understanding complex socio-technical change. According to the authors, whilst SPT provides a better understanding of the dynamics and changing patterns of conventional everyday practices, the creation of novel sustainable systems and regimes is better understood by an MLP approach. Hence, a combination of practice theories with other theoretical approaches can provide better insight into future energy transitions.

The results and findings of this thesis are by no means an ending, but rather a beginning. The answers obtained through this research work have led to many more questions; questions about the importance of practices, their boundaries, their spatio-temporality and their transferability; the optimal scale for societal transitions for sustainability; and the agency of architects and architecture in design

interventions. Indeed, one of the greatest achievements for the author through this PhD dissertation is beginning to ask the right kind of questions.

BIBLIOGRAPHY

ADB, 2009. Pakistan: Sustainable Energy Efficiency Development Program (Technical Assistance Consultant's Final Report. Prepared by Hagler Bailly Pakistan and Econoler International No. ADB TA 7060-PAK). Asian Development Bank (ADB), Islamabad.

Ahmed, M., 2016. Contemporary built form in Pakistan: an analysis of residences and urban areas of Lahore. J. Res. Archit. Plan. 20, 21.

Alahdad, Z., 2012. Pakistan's energy sector: From crises to crises- breaking the chain. Pakistan Institute of Development Economics, Islamabad.

Anderson, B., 2016. Laundry, energy and time: Insights from 20 years of time-use diary data in the United Kingdom. Energy Res. Soc. Sci. 22, 125–136. https://doi.org/10.1016/j.erss.2016.09.004

Anderson, K., Bows, A., 2011. Beyond "dangerous" climate change: emission scenarios for a new world. Philos. Trans. R. Soc. Math. Phys. Eng. Sci. 369, 20–44. https://doi.org/10.1098/rsta.2010.0290

Anis-ur-Rahmaan, Anis, B., 2009. Dynamics of gated communities, their impact and challenges for sustainable development: A case study of Lahore, Pakistan. Int. J. Archit. Res. ArchNet-IJAR 3, 57–70.

Aslam, W., Soban, M., Akhtar, F., Zaffar, N.A., 2015. Smart meters for industrial energy conservation and efficiency optimization in Pakistan: Scope, technology and applications. Renew. Sustain. Energy Rev. 44, 933–943. https://doi.org/10.1016/j.rser.2015.01.004

Atkinson, P., Coffey, A., 2003. Revisiting the relationship between participant observation and interviewing, in: Holstein, J.A., Gubrium, J.F. (Eds.), Postmodern Interviewing. SAGE Publications, Inc., London, pp. 108–122. https://doi.org/10.4135/9781412984492

Awan, N., Schneider, T., Till, J., 2011a. Spatial agency: other ways of doing architecture. Routledge, Abingdon, Oxon [England]; New York, NY.

Awan, N., Schneider, T., Till, J., 2011b. Spatial agency: other ways of doing architecture. Routledge, Abingdon, Oxon [England]; New York, NY.

Aziz, A.A., Mustapha, N.H.N., Ismail, R., 2013. Factors Affecting Energy Demand in Developing Countries: A Dynamic Panel Analysis. Int. J. Energy Econ. Policy 3, 1–6.

Bajwa, I.U., Ahmad, I., Khan, Z., 2008. Urban Housing Development in Pakistan; A Case Study Of Lahore Metropolitan Area.

Bajwa, K.W. (Ed.), 2013. Urban Pakistan: frames for imagining and reading urbanism, Oxford in Pakistan readings in sociology and social anthropology. Oxford University Press, Karachi, Pakistan.

Bartiaux, F., Gram-Hanssen, K., Fonseca, P., Ozoliņa, L., Christensen, T.H., 2014. A practice–theory approach to homeowners' energy retrofits in four European areas. Build. Res. Inf. 42, 525–538. https://doi.org/10.1080/09613218.2014.900253

Bates, O., Clear, A.K., Friday, A., Hazas, M., Morley, J., 2012. Accounting for Energy-Reliant Services within Everyday Life at Home, in: Proceeding of the Pervasive Computing 10th International Conference. Presented at the Pervasive 2012, Springer Berlin Heidelberg, Newcastle, UK, pp. 107–124. https://doi.org/10.1007/978-3-642-31205-2_8

Bazeley, P., Jackson, K., 2013. Qualitative Data Analysis with NVivo. Sage Publications Ltd.

Becker, H., Geer, B., 1957. Participant Observation and Interviewing: A Comparison, in: Filstead, W.J. (Ed.), Human Organization. Markham, Chicago, pp. 28–32.

Becker, R., Foliente, G., 2005. Performance Based International State of the Art (PeBBu 2nd International SotA Report EUR 21989 No. CIBdf), Performance Based Building Thematic Network 2001-2005. Performance Based Building Thematic Network 2001-2005, Rotterdam.

Behar, C., 2016. A Socio-technical perspective of ventilation practices in UK social housing with whole house ventilation systems; Everyday life and change (PhD Thesis). University College London.

Bennett, T., Savage, M., Silva, E., Warde, A., Gayo-Cal, M., Wright, D., 2009. Culture, Class, Distinction. Routledge, London.

Berry, E., 2014. Religion and Sustainability in Global Civil Society: Some Basic Findings from Rio+20. Worldviews 18, 269–288.

Berry, E., 2013. Religious Environmentalism and Environmental Religion in America. Relig. Compass 7, 454–466. https://doi.org/10.1111/rec3.12065

Bhan, G., 2017. From the *basti* to the 'house': Socio-spatial readings of housing policy in India. Curr. Sociol. 65, 587–602. https://doi.org/10.1177/0011392117697465

Bhutto, A.W., Bazmi, A.A., Zahedi, G., 2011. Greener energy: Issues and challenges for Pakistan—Biomass energy prospective. Renew. Sustain. Energy Rev. 15, 3207–3219. https://doi.org/10.1016/j.rser.2011.04.015

Bhutto, A.W., Yasin, M., 2010. Overcoming the Energy Efficiency gap in Pakistan's Household Sector. Presented at the International conference on energy systems engineering (ICESE-2010), COMSATS, Islamabad.

Bierwirth, A., Thomas, S., 2015. Almost best friends: sufficiency and efficiency, in: ECEEE Summer Study Proceedings. Presented at the ECEEE Summer Study Proceedings, European Council for an Energy Efficient Economy (ECEEE), Toulon/Hyères, France, pp. 71–82.

Blank, Y., Rosen-Zvi, I., 2010. Introduction: The spatial turn in social theory. Hagar Beer-Sheva 10, 3-8,151-152.

Bourdieu, P., 1996. Physical space, social space and habitus. Vilhelm Aubert Meml. Lect. Rep. 10.

Bourdieu, P., 1986. The forms of capital, in: Richardson, J. (Ed.), Handbook of Theory and Research for the Sociology of Education. Greenwood Press, Westport, CT, pp. 241–258. https://doi.org/10.1002/9780470755679.ch15

Bourdieu, P., 1984. Distinction: A Social Critique of the Judgement of Taste, Translated by Richard Nice. Harvard University Press, Cambridge, Massachusetts.

Bourdieu, P., 1981. Men and machines, in: Cetina, K.K., Cicourel, A.V. (Eds.), Advances in Social Theory and Methodology: Toward an Integration of Micro- and Macro-Sociologies. Routledge & Kegan Paul, Boston, pp. 304–317.

Bourdieu, P., 1977. Outline of a Theory of Practice. Cambridge University Press.

Bourdieu, P., 1970. The Berber house or the world reversed. Inf. Int. Soc. Sci. Counc. 9, 151–170.

Brand, S., 1994. How Buildings Learn: What happens after they're built. Penguin Books, London, New York.

Brew-Hammond, A., 2010. Energy access in Africa: Challenges ahead. Energy Policy 38, 2291–2301. https://doi.org/10.1016/j.enpol.2009.12.016

Browne, A.L., 2016. Histories, Trajectories and Patterns of Cleanliness, Energy and Water Consumption: Reflections on China. DEMAND Centre Conference Lancaster.

Browne, A.L., Pullinger, M., Medd, W., Anderson, B., 2014. Patterns of practice: a reflection on the development of quantitative/mixed methodologies capturing everyday life related to water consumption in the UK. Int. J. Soc. Res. Methodol. 17, 27–43. https://doi.org/10.1080/13645579.2014.854012

Buchanan, K., Russo, R., Anderson, B., 2015. The question of energy reduction: The problem(s) with feedback. Energy Policy 77, 89–96. https://doi.org/10.1016/j.enpol.2014.12.008

Calwell, C., 2010. Is efficient sufficient? The case for shifting our emphasis in energy specifications to progressive efficiency and sufficiency (Report for the European Council of Energy Efficient Economy (ECEEE)). ECEEE, Stockholm, Sweden.

Chan, J., 2015. Moral Agency in Architecture? The Dialectics of Spatializing Morality and Moralizing Spaces, in: Muller, A.-L., Reichmann, W. (Eds.), Architecture, Materiality and Society: Connecting Sociology of Architecture with Science and Technology Studies. Palgrave Macmillan, Houndmills, Basingstoke, Hampshire, pp. 198–214.

Chatterton, D.T., 2011. An Introduction to Thinking About 'Energy Behaviour': a multi-model approach. Department of Energy and Climate Change.

Chaudhry, T.T., 2010. Estimating residential electricity demand responses in Pakistan's Punjab. Lahore J. Econ. 15, 107–138.

Crawford, M., 1991. Can Architects Be Socially Responsible?, in: Ghirardo, D. (Ed.), Out of Site: A Social Criticism of Architecture. Bay Pres, Seattle, pp. 27–45.

Crosbie, T., Baker, K., 2010. Energy-efficiency interventions in housing: learning from the inhabitants. Build. Res. Inf. 38, 70–79. https://doi.org/10.1080/09613210903279326

Darby, S., 2010. Smart metering: what potential for householder engagement? Build. Res. Inf. 38, 442–457. https://doi.org/10.1080/09613218.2010.492660

Darmon, I., Warde, A., 2016. Senses and Sensibilities: Stabilising and Changing Tastes in Cross-National Couples. Food Cult. Soc. 19, 705–722. https://doi.org/10.1080/15528014.2016.1243769

de Jong, A., Kuijer, L., Rydell, T., 2013. Balancing food values: Making sustainable choices within cooking practices, in: Proceedings of the Nordes Design Research Conference 2013. Copenhagen/Malmö, pp. 127–135.

Dilley, L.T.M., 2015. Governing Our Choices: 'Proenvironmental Behaviour' as a Practice of Government. Environ. Plan. C Gov. Policy 33, 272–288. https://doi.org/10.1068/c12321

Durand-Daubin, M., Anderson, B., 2018. Changing Eating Practices in France and Great Britain: Evidence from Time-Use Data and Implications for Direct Energy Demand, in: Hui, A., Day, R., Walker, G. (Eds.), Demanding Energy. Springer International Publishing, Cham, pp. 205–231. https://doi.org/10.1007/978-3-319-61991-0_10

Dutton, T.A., Mann, L.H. (Eds.), 1996. Reconstructing Architecture: Critical Discourses and Social Practices, Pedagogy and Cultural Practice. University of Minnesota Press, Minneapolis London.

Edwards, B., Sibly, M., Hakmi, M., Land, P. (Eds.), 2006. Courtyard housing: past, present, and future. Taylor & Francis, Abingdon; New York.

EIA, 2018. Glossary - U.S. Energy Information Administration (EIA) [WWW Document]. US Energy Inf. Adm. URL https://www.eia.gov/tools/glossary/index.php?id=E (accessed 12.21.18).

EIA, 2016. International Energy Outlook 2016. U.S. Energy Information Administration (EIA), Washington, D.C.

Ek, K., Söderholm, P., 2010. The devil is in the details: Household electricity saving behavior and the role of information. Energy Policy 38, 1578–1587. https://doi.org/10.1016/j.enpol.2009.11.041

Ellegård, K., Palm, J., 2011. Visualizing energy consumption activities as a tool for making everyday life more sustainable. Appl. Energy 88, 1920–1926. https://doi.org/10.1016/j.apenergy.2010.11.019

Ellsworth-Krebs, K., Reid, L., 2016. Conceptualising energy prosumption: Exploring energy production, consumption and microgeneration in Scotland, UK. Environ. Plan. Econ. Space 48, 1988–2005. https://doi.org/10.1177/0308518X16649182

Fallan, K., 2008. Architecture in action: Traveling with actor-network theory in the land of architectural research. Archit. Theory Rev. 13, 80–96. https://doi.org/10.1080/13264820801918306

Farooqui, R.U., Ahmed, S.M., Lodi, S.H., 2008. Assessment of Pakistani Construction Industry – Current Performance and the Way Forward. J. Adv. Perform. Inf. Value, CIBW117 1.

FBR, 2018. Finance Act, 2018 - Explanation of important amendments made in the Income Tax Ordinance, 2001 (Income Tax circulars No. C.No.4(69)1T-Budgetl2018-109192-R). Federal Board of Revenue, Government of Pakistan, Islamabad.

Flyvbjerg, Bent, 2006. Five Misunderstandings About Case-Study Research. Qual. Inq. 12, 219–245. https://doi.org/10.1177/1077800405284363

Flyvbjerg, B., 2006. Five misunderstandings about case-study research. Qual. Inq. 12, 219–245. https://doi.org/10.1177/1077800405284363

Foliente, G.C., 2000. Developments in performance-based building codes and standards. For. Prod. J. Madison 50, 12–21.

Forsey, M.G., 2010. Ethnography as participant listening. Ethnography 11, 558–572. https://doi.org/10.1177/1466138110372587

Foulds, C., 2018. Advancing energy policy: lessons on the integration of social sciences and humanities. Springer Berlin Heidelberg, New York, NY.

Foulds, C., Powell, J., Seyfang, G., 2013. Investigating the performance of everyday domestic practices using building monitoring. Build. Res. Inf. 41, 622–636. https://doi.org/10.1080/09613218.2013.823537

Foulds, C., Robison, R.A.V., Macrorie, R., 2017. Energy monitoring as a practice: Investigating use of the iMeasure online energy feedback tool. Energy Policy 104, 194–202. https://doi.org/10.1016/j.enpol.2017.01.055

Freud, S., 1919. The “Uncanny,” in: Freud, S., Strachey, J., Freud, A., Strachey, A., Tyson, A. (Eds.), The Standard Edition of the Complete Psychological Works of Sigmund Freud. An Infantile Neurosis and Other Works. Hogarth Press, London, pp. 217–256.

Friis, F., Christensen, T.H., 2016. The challenge of time shifting energy demand practices: Insights from Denmark. Energy Res. Soc. Sci. 19, 124–133. https://doi.org/10.1016/j.erss.2016.05.017

Fuller, M.G., Löw, M., 2017. Introduction: An invitation to spatial sociology. Curr. Sociol. 65, 469–491. https://doi.org/10.1177/0011392117697461

Galvin, R., 2015. How many interviews are enough? Do qualitative interviews in building energy consumption research produce reliable knowledge? J. Build. Eng. 1, 2–12. https://doi.org/10.1016/j.jobe.2014.12.001

Galvin, R., Gubernat, A., 2016. The rebound effect and Schatzki's social theory: Reassessing the socio-materiality of energy consumption via a German case study. Energy Res. Soc. Sci. 22, 183–193. https://doi.org/10.1016/j.erss.2016.08.024

Galvin, R., Sunikka-Blank, M., 2016. Schatzkian practice theory and energy consumption research: Time for some philosophical spring cleaning? Energy Res. Soc. Sci. 22, 63–68. https://doi.org/10.1016/j.erss.2016.08.021

Gans, H.J., 2002. The sociology of space: A use-centered view. City Community 1, 329–339. https://doi.org/10.1111/1540-6040.00027

Geels, F.W., 2010. Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. Res. Policy 39, 495–510. https://doi.org/10.1016/j.respol.2010.01.022

Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Res. Policy, NELSON + WINTER + 20 31, 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

Ghani, J.A., 2014. The emerging middle class in Pakistan: how it consumes, earns, and saves, in: International Conference on Marketing. Presented at the IBAICM 2014, Institute of Business Administration (IBA) Karachi, Karachi.

Gherardi, S., 2012. How to Conduct a Practice-based Study: Problems and Methods. Edward Elgar Publishing.

Giddens, A., 1993. Preface, in: Society Action and Space: An Alternative Human Geography. Routledge, London, pp. xii–xv.

Giddens, A., 1985. Time, Space and Regionalisation, in: Social Relations and Spatial Structures, Critical Human Geography. Palgrave, London, pp. 265–295. https://doi.org/10.1007/978-1-349-27935-7_12

Giddens, A., 1984a. Space, Time, and Politics in Social Theory: An Interview with Anthony Giddens. Environ. Plan. Soc. Space 2, 123–132. https://doi.org/10.1068/d020123

Giddens, A., 1984b. The Constitution of Society: Outline of the Theory of Structuration. University of California Press.

Giddens, A., 1981. A contemporary critique of historical materialism. University of California Press, Berkeley.

Gieryn, T.F., 2002. What buildings do. Theory Soc. 31, 35–74.

Gieryn, T.F., 2000. A Space for Place in Sociology. Annu. Rev. Sociol. 26, 463–496.

Gill, Z.M., Tierney, M.J., Pegg, I.M., Allan, N., 2010. Low-energy dwellings: the contribution of behaviours to actual performance. Build. Res. Inf. 38, 491–508. https://doi.org/10.1080/09613218.2010.505371

Glover, W.J., 2008. Making Lahore Modern: Constructing and Imagining a Colonial City. University of Minnesota Press, Minneapolis.

Graaf, R. de, 2017. Four walls and a roof: The complex nature of a simple profession. Harvard University Press, Cambridge, Massachusetts.

Gram-Hanssen, K., 2014a. New needs for better understanding of household's energy consumption – behaviour, lifestyle or practices? Archit. Eng. Des. Manag. 10, 91–107. https://doi.org/10.1080/17452007.2013.837251

Gram-Hanssen, K., 2014b. New needs for better understanding of household's energy consumption – behaviour, lifestyle or practices? Archit. Eng. Des. Manag. 10, 91–107. https://doi.org/10.1080/17452007.2013.837251

Gram-Hanssen, K., 2013. Efficient technologies or user behaviour, which is the more important when reducing households' energy consumption? Energy Effic. 6, 447–457. https://doi.org/10.1007/s12053-012-9184-4

Gram-Hanssen, K., 2011. Understanding change and continuity in residential energy consumption. J. Consum. Cult. 11, 61–78. https://doi.org/10.1177/1469540510391725

Gram-Hanssen, K., 2010. Residential heat comfort practices: understanding users. Build. Res. Inf. 38, 175–186. https://doi.org/10.1080/09613210903541527

Gram-Hanssen, K., 2009. Standby Consumption in Households Analyzed With a Practice Theory Approach. J. Ind. Ecol. 14, 150–165. https://doi.org/10.1111/j.1530-9290.2009.00194.x

Gram-Hanssen, K., 2008. Consuming technologies – developing routines. J. Clean. Prod. 16, 1181–1189. https://doi.org/10.1016/j.jclepro.2007.08.006

Gram-Hanssen, K., Darby, S.J., 2018. "Home is where the smart is"? Evaluating smart home research and approaches against the concept of home. Energy Res. Soc. Sci. 37, 94–101. https://doi.org/10.1016/j.erss.2017.09.037

Gregory, D., Urry, J., 1985. Social relations and spatial structures. Macmillan.

Gronow, J., Warde, A. (Eds.), 2001. Ordinary consumption. Routledge, London; New York.

Grubb, M.J., 1990. Communication Energy efficiency and economic fallacies. Energy Policy 18, 783–785. https://doi.org/10.1016/0301-4215(90)90031-X

Guy, S., Shove, E., 2000. A sociology of energy, buildings, and the environment: constructing knowledge, designing practice. Routledge, London; New York.

Halkier, B., 2017. Questioning the 'gold standard' thinking in qualitative methods from a practice theoretical perspective: Towards methodological multiplicity, in: Jonas, M., Littig, B., Wroblewski, A. (Eds.), Methodological Reflections on Practice Oriented Theories. Springer International Publishing, Cham, Switzerland, pp. 193–204.

Halkier, B., 2009. Suitable Cooking? Food Cult. Soc. 12, 357–377. https://doi.org/10.2752/175174409X432030

Halkier, B., Jensen, I., 2011a. Methodological challenges in using practice theory in consumption research. Examples from a study on handling nutritional contestations of food consumption. J. Consum. Cult. 11, 101–123. https://doi.org/10.1177/1469540510391365

Halkier, B., Jensen, I., 2011b. Doing 'healthier' food in everyday life? A qualitative study of how Pakistani Danes handle nutritional communication. Crit. Public Health 21, 471–483. https://doi.org/10.1080/09581596.2011.594873

Halkier, B., Katz-Gerro, T., Martens, L., 2011a. Applying practice theory to the study of consumption: Theoretical and methodological considerations. J. Consum. Cult. 11, 3–13. https://doi.org/10.1177/1469540510391765

Halkier, B., Katz-Gerro, T., Martens, L., 2011b. Applying practice theory to the study of consumption: Theoretical and methodological considerations. J. Consum. Cult. 11, 3–13. https://doi.org/10.1177/1469540510391765

Hand, M., Shove, E., Southerton, D., 2007. Home Extensions in the United Kingdom: Space, Time, and Practice. Environ. Plan. Soc. Space 25, 668–681. https://doi.org/10.1068/d413t

Hand, M., Shove, E., Southerton, D., 2005. Explaining showering: a discussion of the material, conventional, and temporal dimensions of practice. Sociol. Res. Online 10. https://doi.org/10.5153/sro.1100

Hansen, A., Nielsen, K.B., Wilhite, H., 2016. Staying Cool, Looking Good, Moving Around: Consumption, Sustainability and the 'Rise of the South.' Forum Dev. Stud. 43, 5–25. https://doi.org/10.1080/08039410.2015.1134640

Haque, M.S., 2000. Privatization in Developing Countries: Formal Causes, Critical Reasons, and Adverse Impacts, in: Farazmand, A. (Ed.), Privatization or Public Enterprise Reform?, Privatization or Reform: Public Enterprise Management in Transition. Greenwood Press, Westport, Conn., pp. 217–238.

Harboe, L., 2012. Social concerns in contemporary architecture: three European practices and their works, Context. PhD thesis. Oslo School of Architecture and Design, Oslo.

Hargreaves, T., 2011. Practice-ing behaviour change: Applying social practice theory to pro-environmental behaviour change. J. Consum. Cult. 11, 79–99. https://doi.org/10.1177/1469540510390500

Hargreaves, T., Longhurst, N., Seyfang, G., 2013. Up, Down, round and round: Connecting Regimes and Practices in Innovation for Sustainability. Environ. Plan. A 45, 402–420. https://doi.org/10.1068/a45124

Hatch, C.R., 1984. The Scope of social architecture. Van Nostrand Reinhold, New York.

HDIP, 2018. Pakistan Energy Yearbook 2017. Ministry of Petroleum and Natural Resources, Hydrocarbon Development Institute of Pakistan, Islamabad.

Heidenstrøm, N., Gram-Hanssen, K., Strandbakken, P., Toke Haunstrup Christensen, 2013. Changed norms of comfort in different energy cultures: The case of heat pumps, in: Rethink, Renew, Restart. Presented at the ECEEE Summer Study Proceedings, European Council for an Energy Efficient Economy (ECEEE), Toulon, pp. 2241–2249.

Higginson, S., McKenna, E., Hargreaves, T., Chilvers, J., Thomson, M., 2015. Diagramming social practice theory: An interdisciplinary experiment exploring practices as networks. Indoor Built Environ. 24, 950–969. https://doi.org/10.1177/1420326X15603439

Higginson, S., Thomson, M., Bhamra, T., 2014. "For the times they are a-changin": the impact of shifting energy-use practices in time and space. Local Environ. 19, 520–538. https://doi.org/10.1080/13549839.2013.802459

Hitchcock, G., 1993. An integrated framework for energy use and behaviour in the domestic sector. Energy Build. 20, 151–157. https://doi.org/10.1016/0378-7788(93)90006-G

Hitchings, R., 2012. People can talk about their practices. Area 44, 61–67. https://doi.org/10.1111/j.1475-4762.2011.01060.x

Ho, E., 2015. Bound by ethical complexities and socio-material histories: an exploration of household energy consumption in Singapore. Energy Res. Soc. Sci. 10, 150–164. https://doi.org/10.1016/j.erss.2015.07.016

Horta, A., Wilhite, H., Schmidt, L., Bartiaux, F., 2014. Socio-Technical and Cultural Approaches to Energy Consumption: An Introduction. Nat. Cult. 9. https://doi.org/10.3167/nc.2014.090201

Hughes, T.P., 1993. Networks of Power: Electrification in Western Society, 1880-1930. JHU Press.

Hui, A., Schatzki, T.R., Shove, E., 2017. The Nexus of Practices: Connections, Constellations, Practitioners. Taylor & Francis, Abingdon; New York.

Hutton, R.B., Mauser, G.A., Filiatrault, P., Ahtola, O.T., 1986. Effects of Cost-Related Feedback on Consumer Knowledge and Consumption Behavior: A Field Experimental Approach. J. Consum. Res. 13, 327. https://doi.org/10.1086/209072

Imrie, R., Street, E., 2014. Autonomy and the socialisation of architects. J. Archit. 19, 723–739. https://doi.org/10.1080/13602365.2014.967271

IRENA, 2018. Renewables Readiness Assessment: Pakistan. International Renewable Energy Agency (IRENA), Abu Dhabi.

Irfan, M., Iqbal, J., Iqbal, A., Iqbal, Z., Riaz, R.A., Mehmood, A., 2017. Opportunities and challenges in control of smart grids – Pakistani perspective. Renew. Sustain. Energy Rev. 71, 652–674. https://doi.org/10.1016/j.rser.2016.12.095

Jack, T., 2013. Laundry routine and resource consumption in Australia. Int. J. Consum. Stud. 37, 666–674. https://doi.org/10.1111/ijcs.12048

Jan, F., Mutalib, A., 2013. Mitigation of Energy Crisis in Pakistan through Energy Conservation in Residential Sector. Int. J. Res. Eng. Technol. 2, 2277 – 4378.

Janda, K.B., 2011. Buildings don't use energy: people do. Archit. Sci. Rev. 54, 15–22. https://doi.org/10.3763/asre.2009.0050

Janda, K.B., Parag, Y., 2013. A middle-out approach for improving energy performance in buildings. Build. Res. Inf. 41, 39–50. https://doi.org/10.1080/09613218.2013.743396

Jensen, C.L., Wade, F., Pettersen, I.N., Kuijer, L., 2014. How do material objects transcend the boundaries between professional and domestic practices?, in: Foulds, C., Jensen, C.L. (Eds.), Practices, the Built Environment and Sustainability – A Thinking Note Collection. GSI, DIST, BSA CCSG., Cambridge, Copenhagen, London.

Jonas, M., Littig, B., Wroblewski, A. (Eds.), 2017. Methodological Reflections on Practice Oriented Theories. Springer International Publishing.

Judson, E.P., Maller, C., 2014. Housing renovations and energy efficiency: insights from homeowners' practices. Build. Res. Inf. 42, 501–511. https://doi.org/10.1080/09613218.2014.894808

Karakosta, C., Askounis, D., 2010. Developing countries' energy needs and priorities under a sustainable development perspective: A linguistic decision support approach. Energy Sustain. Dev. 14, 330–338. https://doi.org/10.1016/j.esd.2010.07.008

Karvonen, A., 2013. Towards systemic domestic retrofit: a social practices approach. Build. Res. Inf. 41, 563–574. https://doi.org/10.1080/09613218.2013.805298

Kemp, R., Loorbach, D., 2006. Transition management: a reflexive governance approach, in: Voss, J., D. Bauknecht, Kemp, R. (Eds.), Reflexive Governance for Sustainable Development. Edward Elgar Publishing, Cheltenham, Glos, pp. 103–130.

Khalid, R., Sunikka-Blank, M., 2018. Evolving houses, demanding practices: A case of rising electricity consumption of the middle class in Pakistan. Build. Environ. 143, 293–305. https://doi.org/10.1016/j.buildenv.2018.07.010

Khalid, R., Sunikka-Blank, M., 2017. Homely social practices, uncanny electricity demands: Class, culture and material dynamics in Pakistan. Energy Res. Soc. Sci. 34, 122–131. https://doi.org/10.1016/j.erss.2017.06.038

Khan, M., 1994. Cultural Transfers: The Repossession of Architectural Form. Environ. Des. J. Islam. Environ. Des. Res. Cent. 1-2 84–103.

Khan, M.A., 1983. "Informal" architecture: an examination of some adaptive processes in architectural traditions (MSc thesis). Massachusetts Institute of Technology.

Khazzoom, J.D., 1980. Economic Implications of Mandated Efficiency in Standards for Household Appliances. Energy J. 1, 21–40.

King, A., 1990. Architecture, Capital and the Globalization of Culture: Theory Cult. Soc. 7, 397–411. https://doi.org/10.1177/026327690007002023

King, A.D., 1984. The Bungalow: The Production of a Global Culture. Routledge & Kegan Paul, London.

Knox, P.L., 1987. The Social Production of the Built Environment Architects, Architecture and the Post-Modern City. Prog. Hum. Geogr. 11, 354–377. https://doi.org/10.1177/030913258701100303

Krämer, H., 2017. Creativity at work: Methodological challenges for a praxeological research program, in: Jonas, M., Littig, B., Wroblewski, A. (Eds.), Methodological Reflections on Practice Oriented Theories. Springer International Publishing, Cham, Switzerland, pp. 205–219.

Kreft, S., Eckstein, D., Junghans, L., Kerestan, C., Hagen, U., 2015. Global Climate Risk Index 2015: Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2013 and 1994 to 2013. GermanWatch e.V., German Federal Ministry for Economic Cooperation and Development (BMZ), Berlin.

Kuijer, L., 2014. Implications of social practice theory for sustainable design (PhD dissertation). Delft University of Technology.

Kuijer, L., Jong, A. de, Eijk, D. van, 2013. Practices as a unit of design: An exploration of theoretical guidelines in a study on bathing. ACM Trans. Comput.-Hum. Interact. 20, 1–22. https://doi.org/10.1145/2493382

Kuijer, L., Watson, M., 2017. 'That's when we started using the living room': Lessons from a local history of domestic heating in the United Kingdom. Energy Res. Soc. Sci. 28, 77–85. https://doi.org/10.1016/j.erss.2017.04.010

Kvale, S., 1996. InterViews: An Introduction to Qualitative Research Interviewing. Sage Publications, Inc, London.

Latour, B., 2005a. Reassembling the social: an introduction to actor-network-theory, Clarendon lectures in management studies. Oxford University Press, Oxford ; New York.

Latour, B., 2005b. Reassembling the social: an introduction to actor-network-theory, Clarendon lectures in management studies. Oxford University Press, Oxford ; New York.

Latour, B., Yaneva, A., 2008. Give me a gun and I will make all buildings move: An ANT's view of architecture. Explor. Archit. Teach. Des. Res. 80–89.

LDA, 2004. Integrated Master Plan of Lahore (IMPL)-2021 (Volume 1: Existing Scenario). Prepared by NESPAK for Lahore Development Authority (LDA), Lahore.

Lefebvre, H., 1992. The Production of Space. Wiley.

Lemanski, C., 2017. Citizens in the middle class: The interstitial policy spaces of South Africa's housing gap. Geoforum 79, 101–110. https://doi.org/10.1016/j.geoforum.2016.12.011

LIT, 1941. Annual Administration Report of Lahore Improvement Trust 1940-41 (Annual Administrative Report). Government of Punjab, Pakistan, Lahore.

Littig, B., Leitner, M., 2017. Combining Methods in Practice Oriented Research: A multi-method case study on sustainable cohousing, in: Methodological Reflections on Practice Oriented Theories. Springer, Cham, Switzerland, pp. 161–175. https://doi.org/10.1007/978-3-319-52897-7_11

Löfström, E., Palm, J., 2008. Visualising Household Energy Use in the Interest of Developing Sustainable Energy Systems. Hous. Stud. 23, 935–940. https://doi.org/10.1080/02673030802425602

Loorbach, D., Frantzeskaki, N., Avelino, F., 2017. Sustainability Transitions Research: Transforming Science and Practice for Societal Change. Annu. Rev. Environ. Resour. 42, 599–626. https://doi.org/10.1146/annurev-environ-102014-021340

Lorne, C., 2017. Spatial agency and practising architecture beyond buildings. Soc. Cult. Geogr. 18, 268–287. https://doi.org/10.1080/14649365.2016.1174282

Löw, M., 2013. The City as Experiential Space: The Production of Shared Meaning: The production of meaning in the city. Int. J. Urban Reg. Res. 37, 894–908. https://doi.org/10.1111/1468-2427.12022

Lutzenhiser, L., 2014. Through the energy efficiency looking glass. Energy Res. Soc. Sci. 1, 141–151. https://doi.org/10.1016/j.erss.2014.03.011

Lutzenhiser, L., 1992. A cultural model of household energy consumption. Energy 17, 47–60. https://doi.org/10.1016/0360-5442(92)90032-U

Ma, Z., Cooper, P., Daly, D., Ledo, L., 2012. Existing building retrofits: Methodology and state-of-the-art. Energy Build. 55, 889–902. https://doi.org/10.1016/j.enbuild.2012.08.018

Macrorie, R., 2012. The dynamics and governance of thermal comfort practices in low carbon housing: A comparative analysis of domestication theory and theories of social practice. Presented at the 3S Working Paper 2012-16, Science, Society and Sustainability Research Group, Norwich.

Macrorie, R.M., Foulds, C., Hargreaves, T., 2015. Governing and governed by practices: Exploring interventions in low-carbon housing policy and practice, in: Strengers, Y., Maller, C. (Eds.), Social Practices, Intervention and Sustainability: Beyond Behaviour Change, Routledge Studies in Sustainability. Routledge, London New York, pp. 95–111.

Maller, C., 2011. Practices involving energy and water consumption in migrant households, in: Newton, P. (Ed.), Urban Consumption. CSIRO Publishing, Collingwood, Australia, pp. 237–250. https://doi.org/10.1071/9780643103511

Maller, C., Horne, R., Dalton, T., 2012. Green Renovations: Intersections of Daily Routines, Housing Aspirations and Narratives of Environmental Sustainability. Hous. Theory Soc. 29, 255–275. https://doi.org/10.1080/14036096.2011.606332

Marres, N., 2011. The costs of public involvement: everyday devices of carbon accounting and the materialization of participation. Econ. Soc. 40, 510–533. https://doi.org/10.1080/03085147.2011.602294

Martens, L., Scott, S., 2017. Understanding everyday kitchen life: Looking at performance, into performances and for practices, in: Jonas, M., Littig, B., Wroblewski, A. (Eds.), Methodological Reflections on Practice Oriented Theories. Springer International Publishing, Cham, Switzerland, pp. 171–191.

Masood, A., 2010. Gap Analysis on Energy Efficiency (ESCAP Project on "Strengthening Institutional Capacity to Support Energy Efficiency in Selected Asian Countries"). UNESCAP, SAARCH Energy Centre.

Matsuhashi, N., Kuijer, L., De Jong, A.M., 2009. A culture-inspired approach to gaining insights for designing sustainable practices, in: EcoDesign 2009. Presented at the Proceedings of the 6th International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Japan Society of Mechanical Engineers, Sapporo, Japan.

McMeekin, A., Southerton, D., 2012. Sustainability transitions and final consumption: practices and socio-technical systems. Technol. Anal. Strateg. Manag. 24, 345–361. https://doi.org/10.1080/09537325.2012.663960

McNeill, D., 2006. Globalization and the ethics of architectural design. City 10, 49–58. https://doi.org/10.1080/13604810600594639

Menezes, A.C., Cripps, A., Bouchlaghem, D., Buswell, R., 2012. Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reduce the performance gap. Appl. Energy 97, 355–364. https://doi.org/10.1016/j.apenergy.2011.11.075

Miles, M.B., Huberman, A.M., Saldaña, J., 2014. Qualitative data analysis: a methods sourcebook, 3rd ed. SAGE Publications, California, US.

Miller, D. (Ed.), 2001. Home possessions: material culture behind closed doors. Berg, Oxford.

Moezzi, M., Lutzenhiser, L., 2010. What's Missing in Theories of the Residential Energy User, in: ACEEE Summer Study on Energy Efficiency in Buildings. ACEEE, Pacific Grove, California, p. 15.

MoHW, 2001. National Housing Policy 2001. Ministry of Housing & Works, Government of Pakistan, Islamabad.

Müller, A.-L., Reichmann, W. (Eds.), 2015. Architecture, materiality and society: connecting sociology of architecture with science and technology studies. Palgrave Macmillan, Basingstoke.

Mumtaz, K.K., 1999. Modernity and Tradition: Contemporary Architecture in Pakistan. Oxford University Press.

Mumtaz, K.K., 1985. A case for indigenous development, in: Powell, R. (Ed.), Regionalism in Architecture, Exploring Architecture in Islamic Cultures 2. Published for the Aga Khan Award for Architecture, 1985 by Concept Media, Singapore, pp. 55–57.

Mylan, J., Southerton, D., 2017. The Social Ordering of an Everyday Practice: The Case of Laundry. Sociology 003803851772293. https://doi.org/10.1177/0038038517722932

National Audit Office, 2016. Green Deal and Energy Company Obligation (No. HC 607). Department of Energy & Climate Change, National Audit Press Office, London.

National Housing Policy Pakistan, 2001. National Housing Policy. Ministry of Housing & Works, Government of Pakistan, Islamabad.

Naus, J., Spaargaren, G., van Vliet, B.J.M., van der Horst, H.M., 2014. Smart grids, information flows and emerging domestic energy practices. Energy Policy 68, 436–446. https://doi.org/10.1016/j.enpol.2014.01.038

Nicholls, L., Strengers, Y., 2015. Peak demand and the 'family peak' period in Australia: Understanding practice (in)flexibility in households with children. Energy Res. Soc. Sci. 9, 116–124. https://doi.org/10.1016/j.erss.2015.08.018

Nichols, L., 2014. Social desire paths: a new theoretical concept to increase the usability of social science research in society. Theory Soc. 43, 647–665. https://doi.org/10.1007/s11186-014-9234-3

Nicol, J.F., Humphreys, M.A., 2002. Adaptive thermal comfort and sustainable thermal standards for buildings. Energy Build. 34, 563–572. https://doi.org/10.1016/S0378-7788(02)00006-3

Nicolini, D., 2017. Is small the only beautiful? Making sense of "large phenomenoa" from a practice-based perspective, in: Hui, A., Schatzki, T., Shove, E. (Eds.), The Nexus of Practices: Connections, Constellations, Practitioners. Routledge, Oxon, pp. 98–113.

Norman, D.A., 2002. The Design of Everyday Things. Basic Books, Inc, New York, NY, USA.

O'Neill, K., Clear, A.K., Friday, A.J., Hazas, M., 2019. "Fractures" in food practices: exploring transitions towards sustainable food - Northumbria Research Link. Agric. Hum. Values.

Oonsivilai, A., Greyson, K.A., 2009. Effect of electric power shedding on economic dispatch: Case study Tanzania, in: 2009 4th IEEE Conference on Industrial Electronics and Applications. Presented at the 2009 4th IEEE Conference on Industrial Electronics and Applications (ICIEA), IEEE, Xian, China, pp. 3252–3255. https://doi.org/10.1109/ICIEA.2009.5138803

Palm, J., Reindl, K., 2016. Understanding energy efficiency in Swedish residential building renovation: A practice theory approach. Energy Res. Soc. Sci. 11, 247–255. https://doi.org/10.1016/j.erss.2015.11.006

Palmer, J., Godoy-Shimizu, D., Tillson, A., Mawditt, I., 2016. Building Performance Evaluation Programme: Findings from domestic projects- Making reality match design. Innovate UK, Swindon, UK.

Palmer, M., Finlay, V., 2003. Faith in Conservation: New Approaches to Religions and the Environment, 1st ed, (Directions in Development - Human Development). World Bank Publications, Washington, D.C.

Pantzar, M., Shove, E., 2010. Understanding innovation in practice: a discussion of the production and re-production of Nordic Walking. Technol. Anal. Strateg. Manag. 22, 447–461. https://doi.org/10.1080/09537321003714402

PBS, 2015. Household Integrated Economic Survey (HIES) 2013-14. Pakistan Bureau of Statistics, Government of Pakistan, Islamabad.

Peters, M.A., Kessl, F., 2009. Space, Time, History: The Reassertion of Space in Social Theory. Policy Futur. Educ. 7, 20–30. https://doi.org/10.2304/pfie.2009.7.1.20

Petherbridge, G.T., 1978. Vernacular Architecture: The House and Society, in: Michell, G. (Ed.), Architecture of the Islamic World: Its History and Social Meaning. Thames and Hudson Ltd, London, pp. 176–208.

Pfau-Effinger, B., 2010. Cultural and Institutional Contexts, in: Treas, J., Drobnič, S. (Eds.), Dividing the Domestic: Men, Women, and Household Work in Cross-National Perspective, Studies in Social Inequality. Stanford University Press, Stanford, Calif, pp. 125–146.

Pierce, J., Paulos, E., 2010. Materializing energy, in: Proceedings of the 8th ACM Conference on Designing Interactive Systems. ACM, pp. 113–122.

Pink, S., Tutt, D., Dainty, A., 2013. Ethnographic Research in the Construction Industry. Routledge.

Pisello, A.L., Asdrubali, F., 2014. Human-based energy retrofits in residential buildings: A cost-effective alternative to traditional physical strategies. Appl. Energy 133, 224–235. https://doi.org/10.1016/j.apenergy.2014.07.049

Powell, R. (Ed.), 1985. Regionalism in Architecture, Exploring Architecture in Islamic Cultures 2. Published for the Aga Khan Award for Architecture, 1985 by Concept Media, Singapore.

Powells, G., Bulkeley, H., Bell, S., Judson, E., 2014. Peak electricity demand and the flexibility of everyday life. Geoforum 55, 43–52. https://doi.org/10.1016/j.geoforum.2014.04.014

Pramar, V.S., 2005. A Social History of Indian Architecture. Oxford University Press, New Delhi.

Priemus, H., 2007. System Innovation in Spatial Development: Current Dutch Approaches. Eur. Plan. Stud. 15, 992–1006. https://doi.org/10.1080/09654310701448147

Purhonen, S., Gronow, J., Heikkilä, R., Kahma, N., Rahkonen, K., Toikka, A., 2014. Suomalainen maku: Kulttuuripääoma, kulutus ja elämäntyylien sosiaalinen eriytyminen [The Finnish Taste: Cultural Capital, Consumption and the Social Differentiation of Lifestyles]. Gaudeamus Helsinki University Press, Helsinki.

Qadeer, M., 2006. Pakistan: Social and cultural transformations in a Muslim nation. Routledge, Abingdon, Oxon. https://doi.org/10.4324/9780203099681

Rauschmayer, F., Bauler, T., Schäpke, N., 2015. Towards a thick understanding of sustainability transitions — Linking transition management, capabilities and social practices. Ecol. Econ. 109, 211–221. https://doi.org/10.1016/j.ecolecon.2014.11.018

Reckwitz, A., 2012. Affective spaces: a praxeological outlook. Rethink. Hist. 16, 241–258. https://doi.org/10.1080/13642529.2012.681193

Reckwitz, A., 2002a. Toward a theory of social practices: a development in culturalist theorizing. Eur. J. Soc. Theory 5, 243–263.

Reckwitz, A., 2002b. The status of the "material" in theories of culture: From "social structure" to "artefacts." J. Theory Soc. Behav. 32, 195–217.

Redström, J., 2006. Towards user design? On the shift from object to user as the subject of design. Des. Stud. 27, 123–139. https://doi.org/10.1016/j.destud.2005.06.001

Rinkinen, J., 2013. Electricity blackouts and hybrid systems of provision: users and the 'reflective practice.' Energy Sustain. Soc. 3, 25.

Rinkinen, J., Jalas, M., 2017. Moving home: houses, new occupants and the formation of heating practices. Build. Res. Inf. 45, 293–302. https://doi.org/10.1080/09613218.2016.1143299

Rinkinen, J., Jalas, M., Shove, E., 2015. Object Relations in Accounts of Everyday Life. Sociology 49, 870–885. https://doi.org/10.1177/0038038515577910

Rinkinen, J., Shove, E., Smits, M., 2017. Cold chains in Hanoi and Bangkok: Changing systems of provision and practice. J. Consum. Cult. 1–19. https://doi.org/10.1177/1469540517717783

Rinkinen, J., Smits, M., 2016. Conceptualising conjunctions: Understanding change in energy related practices in urban Southeast Asia, in: What Energy Is for: The Making and Dynamics of Demand. Presented at the DEMAND Centre Conference, 13-15 April, DEMAND, Lancaster, p. 9.

Ropke, I., Christensen, T.H., 2013. Transitions in the wrong direction? Digital technologies and daily life, in: Shove, E., Spurling, N. (Eds.), Sustainable Practices: Social Theory and Climate Change. Routledge, Oxfordshire, pp. 49–68.

Røpke, I., Gram-Hanssen, K., Jensen, J.O., 2008. Households' ICT use in an energy perspective, in: Published in Bartolomeo Sapio et al. (Eds.): The Good, the Bad and the Unexpected: The User and the Future of Information and Communication Technologies. Presented at the Proceedings from a conference organized by COST Action 298 "Participation in the Broadband Society," COST Office, Brussels, Moscow 23-25 May 2007, pp. 595–611.

Ropke, I., Gram-Hanssen, K., Jensen, J.O., 2007. Households' ICT use in an energy perspective, in: The Good, the Bad and the Unexpected: The User and the Future of Information and Communication Technologies. Presented at the COST Action 298, Russian Federation, Moscow, pp. 595–611.

Sahakian, M., 2014. Keeping Cool in Southeast Asia: Energy Consumption and Urban Air-Conditioning. Palgrave Macmillan UK.

Salama, M.M.A., Al-Sumaiti, A.S., 2014. Review on issues related to electric energy demand in distribution system for developing countries. Presented at the 3rd IET International Conference on Clean Energy and Technology (CEAT) 2014, Institution of Engineering and Technology, Kuching, Malaysia. https://doi.org/10.1049/cp.2014.1511

Saldana, J., 2015. The Coding Manual for Qualitative Researchers Third Edition, Third edition. ed. SAGE Publications Ltd, Los Angeles ; London.

Sanoff, H., 2007. Special issue on participatory design. Des. Stud., Participatory Design 28, 213–215. https://doi.org/10.1016/j.destud.2007.02.001

Saunders, H.D., 2000. A view from the macro side: rebound, backfire, and Khazzoom-Brookes. Energy Policy 11.

Saunders, M., Lewis, P., Thornhill, A., 2003. Research Methods for Business Students, 3rd ed. Pearson Education, Harlow, England.

Savage, M., Devine, F., Cunningham, N., Taylor, M., Li, Y., Hjellbrekke, J., Le Roux, B., Friedman, S., Miles, A., 2013. A New Model of Social Class? Findings from the BBC's Great British Class Survey Experiment. Sociology 47, 219–250. https://doi.org/10.1177/0038038513481128

Schatzki, T., 2015. Practices, governance and sustainability, in: Strengers, Y., Maller, C. (Eds.), Social Practices, Intervention and Sustainability: Beyond Behaviour Change. Routledge, London, New York, pp. 15–30.

Schatzki, T., 2009. Timespace and the organization of social life, in: Time, Consumption and Everyday Life: Practice, Materiality and Culture. Bloomsbury Academic, Oxford, pp. 35–48.

Schatzki, T., 2006. On Studying the Past Scientifically. Inquiry 49, 380–399. https://doi.org/10.1080/00201740600831505

Schatzki, T.R., 2013. The edge of change: on the emergence, persistence and dissolution of practices, in: Shove, E., Spurling, N. (Eds.), Sustainable Practices: Social Theory and Climate Change. Routledge, Oxfordshire, pp. 31–46.

Schatzki, T.R., 2011. Where the action is (on large social phenomena such as sociotechnical regimes). Sustain. Pract. Res. Group Work. Pap. 1.

Schatzki, T.R., 2010a. Materiality and Social Life. Nat. Cult. 5, 123–149. https://doi.org/10.3167/nc.2010.050202

Schatzki, T.R., 2010b. The timespace of human activity: on performance, society, and history as indeterminate teleological events, Toposophia. Lexington Books, Lanham, Md.

Schatzki, T.R., 2002. The site of the social: A philosophical account of the constitution of social Life and change. Penn State Press.

Schatzki, T.R., 2001. Introduction, in: Schatzki, T.R., Cetina, K.K., Savigny, E. von (Eds.), The Practice Turn in Contemporary Theory. Routledge (Taylor & Francis Group), New York, pp. 1–14.

Schatzki, T.R., 1997. Practices and actions a Wittgensteinian critique of Bourdieu and Giddens. Philos. Soc. Sci. 27, 283–308.

Schatzki, T.R., 1996. Social Practices: A Wittgensteinian Approach to Human Activity and the Social. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511527470

Schatzki, T.R., 1990. Do Social Structures Govern Action? Midwest Stud. Philos. 15, 280–295.

Schatzki, T.R., Knorr Cetina, K., von Savigny, E., 2001. The Practice Turn in Contemporary Theory, 1 edition. ed. Routledge, New York.

Schmidt, S., Weigt, H., 2015. Interdisciplinary energy research and energy consumption: What, why, and how? Energy Res. Soc. Sci. 10, 206–219. https://doi.org/10.1016/j.erss.2015.08.001

Schweber, L., Leiringer, R., 2012. Beyond the technical: a snapshot of energy and buildings research. Build. Res. Inf. 40, 481–492. https://doi.org/10.1080/09613218.2012.675713

Scott, K., Bakker, C., Quist, J., 2012. Designing change by living change. Des. Stud. 33, 279–297. https://doi.org/10.1016/j.destud.2011.08.002

Sharp, L., 2009. Foreword, in: Green Building Through Integrated Design, McGraw-Hill's GreenSource Series. The McGraw-Hill Companies, NewYork, pp. xi–xiv. https://doi.org/10.1036/0071546014

Shen, W., Hao, Q., Mak, H., Neelamkavil, J., Xie, H., Dickinson, J., Thomas, R., Pardasani, A., Xue, H., 2010. Systems integration and collaboration in architecture, engineering, construction, and facilities management: A review. Adv. Eng. Inform. 24, 196–207. https://doi.org/10.1016/j.aei.2009.09.001

Shorto, S., 2007. A tomb of one's own: The Governor's house, Lahore, in: Scriver, P., Prakash, V. (Eds.), Colonial Modernities: Building, Dwelling and Architecture in British India and Ceylon. Routledge, Abingdon, pp. 151–167.

Shove, E., 2017. What is wrong with energy efficiency? Build. Res. Inf. 1–11. https://doi.org/10.1080/09613218.2017.1361746

Shove, E., 2016. Matters of practice, in: The Nexus of Practices: Connections, Constellations, Practitioners. Taylor & Francis, Abingdon; New York, pp. 155–168.

Shove, E., 2014. Putting practice into policy: reconfiguring questions of consumption and climate change. Contemp. Soc. Sci. 9, 415–429. https://doi.org/10.1080/21582041.2012.692484

Shove, E., 2010. Beyond the ABC: Climate Change Policy and Theories of Social Change. Environ. Plan. A 42, 1273–1285. https://doi.org/10.1068/a42282

Shove, E., 2003. Converging conventions of comfort, cleanliness and convenience. J. Consum. Policy 26, 395–418.

Shove, E., 1999. Gaps, barriers and conceptual chasms: theories of technology transfer and energy in buildings. Energy Policy 26, 1105–1112.

Shove, E., Pantzar, M., 2005. Consumers, producers and practices: understanding the invention and reinvention of Nordic walking. J. Consum. Cult. 5, 43–64.

Shove, E., Pantzar, M., Watson, M., 2012. The Dynamics of Social Practice: Everyday Life and how it Changes. SAGE Publications, London.

Shove, E., Southerton, D., 2000. Defrosting the Freezer: From Novelty to Convenience: A Narrative of Normalization. J. Mater. Cult. 5, 301–319. https://doi.org/10.1177/135918350000500303

Shove, E., Trentmann, F., Wilk, R. (Eds.), 2009. Time, Consumption and Everyday Life: Practice, Materiality and Culture. Bloomsbury Academic, Oxford.

Shove, E., Walker, G., 2014. What Is Energy For? Social Practice and Energy Demand. Theory Cult. Soc. 31, 41–58. https://doi.org/10.1177/0263276414536746

Shove, E., Walker, G., 2010. Governing transitions in the sustainability of everyday life. Res. Policy 39, 471–476. https://doi.org/10.1016/j.respol.2010.01.019

Shove, E., Watson, M., Hand, M., Ingram, J., 2007. The Design of Everyday Life. Berg Publishers, New York, NY.

Shove, E., Watson, M., Spurling, N., 2015. Conceptualizing connections: Energy demand, infrastructures and social practices. Eur. J. Soc. Theory 18, 274–287. https://doi.org/10.1177/1368431015579964

Silverstone, R., Hirsch, E., Morley, D., 1991. Listening to a long conversation: An ethnographic approach to the study of information and communication technologies in the home. Cult. Stud. 5, 204–227. https://doi.org/10.1080/09502389100490171

Smits, M., 2015. Southeast Asian Energy Transitions: Between Modernity and Sustainability. Ashgate Publishing, Ltd., Surrey, England ; Burlington, VT.

Smits, M., 2011. Progressive contextualisation of energy practices and trajectories: A case study in Thailand. Rural Soc. 20, 280–293. https://doi.org/10.5172/rsj.20.3.280

Smits, M., Rinkinen, J., 2016. Unpacking convergence/divergence: comparing elements, practices and conjunctions of middle-class households in Bangkok and Hanoi. Presented at the DEMAND.

Southerton, D., 2012. Habits, routines and temporalities of consumption: From individual behaviours to the reproduction of everyday practices. Time Soc. 22, 335–355. https://doi.org/10.1177/0961463X12464228

Southerton, D., 2009. Re-ordering Temporal Rhythms: Coordinating Daily Practices in the UK in 1937 and 2000, in: Shove, E., Trentmann, F., Wilk, R. (Eds.), Time, Consumption and Everyday Life: Practice, Materiality and Culture. Bloomsbury Academic, Oxford, pp. 49–63.

Southerton, D., 2006. Analysing the temporal organization of daily life: Social constraints, practices and their allocation. Sociology 40, 435–454. https://doi.org/10.1177/0038038506063668

Southerton, D., 2003. Squeezing Time' Allocating Practices, Coordinating Networks and Scheduling Society. Time Soc. 12, 5–25.

Southerton, D., Olsen, W., Warde, A., Cheng, S.-L., 2012. Practices and trajectories: A comparative analysis of reading in France, Norway, the Netherlands, the UK and the USA. J. Consum. Cult. 12, 237–262. https://doi.org/10.1177/1469540512456920

Sovacool, B.K., 2014. What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. Energy Res. Soc. Sci. 1, 1–29. https://doi.org/10.1016/j.erss.2014.02.003

Sovacool, B.K., Ryan, S.E., Stern, P.C., Janda, K., Rochlin, G., Spreng, D., Pasqualetti, M.J., Wilhite, H., Lutzenhiser, L., 2015. Integrating social science in energy research. Energy Res. Soc. Sci. 6, 95–99. https://doi.org/10.1016/j.erss.2014.12.005

Spurling, N., 2018. Matters of time: Materiality and the changing temporal organisation of everyday energy consumption. J. Consum. Cult. 0, 1–18. https://doi.org/10.1177/1469540518773818

Spurling, N., McMeekin, A., 2015. Interventions in practices: Sustainable mobility policies in England, in: Strengers, Y., Maller, C. (Eds.), Social Practices, Intervention and Sustainability: Beyond Behaviour Change, Routledge Studies in Sustainability. Routledge, London New York, pp. 95–111.

Spurling, N., McMeekin, A., Shove, E., Southerton, D., Welch, D., 2013. Interventions in practice: re-framing policy approaches to consumer behaviour (Sustainable Practices Research Group). Manchester.

Stern, P., 1992. What Psychology Knows About Energy Conservation. Am. Psychol. 47, 1224–1232.

Stern, P.C., 2014. Individual and household interactions with energy systems: Toward integrated understanding. Energy Res. Soc. Sci. 1, 41–48. https://doi.org/10.1016/j.erss.2014.03.003

Strauss, A., Corbin, J., 1998. Basics of qualitative research: Techniques and procedures for developing grounded theory, 2nd ed., Basics of qualitative research: Techniques and procedures for developing grounded theory, 2nd ed. Sage Publications, Inc, Thousand Oaks, CA, US.

Strengers, Y., 2013. Smart Energy Technologies in Everyday Life: Smart Utopia?, 1st ed. 2013 edition. ed. Palgrave Macmillan, London.

Strengers, Y., 2012. Peak electricity demand and social practice theories: Reframing the role of change agents in the energy sector. Energy Policy 44, 226–234. https://doi.org/10.1016/j.enpol.2012.01.046

Strengers, Y., 2010. Conceptualising everyday practices: composition, reproduction and change. Carbon Neutral Communities Work. Pap.

Strengers, Y., 2008. Comfort expectations: the impact of demand-management strategies in Australia. Build. Res. Inf. 36, 381–391. https://doi.org/10.1080/09613210802087648

Strengers, Y., Maller, C., 2015. Social Practices, Intervention and Sustainability: Beyond behaviour change. Routledge, London, New York.

Strengers, Y., Maller, C., 2011. Integrating health, housing and energy policies: social practices of cooling. Build. Res. Inf. 39, 154–168. https://doi.org/10.1080/09613218.2011.562720

Sunikka-Blank, M., Galvin, R., 2012. Introducing the prebound effect: the gap between performance and actual energy consumption. Build. Res. Inf. 40, 260–273. https://doi.org/10.1080/09613218.2012.690952

Thomas, S., Brischke, L.-A., Thema, J., Kopatz, M., 2015. Energy sufficiency policy: an evolution of energy efficiency policy or radically new approaches?, in: ECEE Summer Study Proceedings. Presented at the ECEE, Toulon, pp. 59–70.

Thompson, P., 1972. Problems of method in oral history. Oral Hist. 1, 1–47.

Thrift, N., 2006. Space. Theory Cult. Soc. 23, 139–146. https://doi.org/10.1177/0263276406063780

Till, J., Schneider, T., 2012. Invisible Agency. Archit. Des. 82, 38–43. https://doi.org/10.1002/ad.1426

Tiwari, P., Rao, J., 2016. Housing markets and housing policies in India, in: ADB Institute, ADBI Working Paper Series.

Tjørring, L., 2016. We forgot half of the population! The significance of gender in Danish energy renovation projects. Energy Res. Soc. Sci. 22, 115–124. https://doi.org/10.1016/j.erss.2016.08.008

Topouzi, M., 2015. Occupants interaction with low-carbon retrofitted homes and its impact on energy use. University of Oxford, Oxford.

Torriti, J., 2014. A review of time use models of residential electricity demand. Renew. Sustain. Energy Rev. 37, 265–272. https://doi.org/10.1016/j.rser.2014.05.034

Torriti, J., Hanna, R., Anderson, B., Yeboah, G., Druckman, A., 2015. Peak residential electricity demand and social practices: Deriving flexibility and greenhouse gas intensities from time use and locational data. Indoor Built Environ. 24, 891–912. https://doi.org/10.1177/1420326X15600776

Torriti, J., Hassan, M.G., Leach, M., 2010. Demand response experience in Europe: Policies, programmes and implementation. Energy 35, 1575–1583. https://doi.org/10.1016/j.energy.2009.05.021

Treas, J., Drobnič, S. (Eds.), 2010. Dividing the domestic: men, women, and household work in cross-national perspective, Studies in social inequality. Stanford University Press, Stanford, Calif.

Trentmann, F., 2009. Disruption is normal: blackouts, breakdowns and the elasticity of everyday life, in: Shove, E., Trentmann, F., Wilk, R. (Eds.), Time, Consumption, and Everyday Life. Berg, Oxford, Oxford, UK, pp. 67–84.

UNDP, 2018. Inclusive Growth in Pakistan. Dev. Advocate Pak. 5.

UNDP, 2013. The rise of the South: Human Progress in a Diverse World (Human Development Report). United Nations Development Programme, New York.

Uzzell, D., 2010. Collective solutions to a global problem. The Psychologist, the joint British Academy/British Psychological Society Annual Lecture, on psychology and climate change 23, 5.

van Dam, S.S., Bakker, C.A., van Hal, J.D.M., 2010. Home energy monitors: impact over the medium-term. Build. Res. Inf. 38, 458–469. https://doi.org/10.1080/09613218.2010.494832

Vidler, A., 1992. The Architectural Uncanny: Essays in the Modern Unhomely. MIT Press, London.

Walker, G., 2014. The dynamics of energy demand: Change, rhythm and synchronicity. Energy Res. Soc. Sci. 1, 49–55. https://doi.org/10.1016/j.erss.2014.03.012

Walker, G., Shove, E., Brown, S., 2014. How does air conditioning become 'needed'? A case study of routes, rationales and dynamics. Energy Res. Soc. Sci. 4, 1–9. https://doi.org/10.1016/j.erss.2014.08.002

Walker, G.C., 1894. Gazetteer of the Lahore District, 1893-94, Lahore District. Lahore Civil and Military Gazette Press, Lahore.

Ward, A., 1996. The supression of the social in design: Architecture as war, in: Reconstructing Architecture: Critical Discourses and Social Practices, Pedagogy and Cultural Practice. University of Minnesota Press, Minneapolis London, pp. 27–70.

Warde, A., 2014. After taste: Culture, consumption and theories of practice. J. Consum. Cult. 14, 279–303. https://doi.org/10.1177/1469540514547828

Warde, A., 2013. What sort of a practice is eating?, in: Shove, E., Spurling, N. (Eds.), Sustainable Practices: Social Theory and Climate Change. Routledge, Oxfordshire, pp. 17–30.

Warde, A., 2005. Consumption and theories of practice. J. Consum. Cult. 5, 131–153.

Warde, A., Southerton, D., 2012. The Habits of Consumption. Helsinki Collegium of Advanced Studies.

Watson, M., 2012. How theories of practice can inform transition to a decarbonised transport system. J. Transp. Geogr. 24, 488–496. https://doi.org/10.1016/j.jtrangeo.2012.04.002

Watson, M., Shove, E., 2008. Product, Competence, Project and Practice: DIY and the dynamics of craft consumption. J. Consum. Cult. 8, 69–89. https://doi.org/10.1177/1469540507085726

Watson, M., Shove, E., 2005. Doing it yourself? Products, competence and meaning in the practices of DIY, in: "Rethinking Inequalities." Presented at the Proceedings of the 7th conference of the European Sociological Association. 9-12 September 2005, ESA, Torun, Poland.

White, L., 1967. The Historical Roots of Our Ecologic Crisis. Science 155, 1203. https://doi.org/10.1126/science.155.3767.1203

Wilhite, H., 2008a. Consumption and the transformation of everyday life: a view from South India. Palgrave Macmillan, Hampshire.

Wilhite, H., 2008b. Consumption and the transformation of everyday life: a view from South India. Palgrave Macmillan, Hampshire.

Wilhite, H., Lutzenhiser, L., 1999. Social Loading and Sustainable Consumption. ACR North Am. Adv. NA-26.

Wilhite, H., Nakagami, H., Masuda, T., Yamaga, Y., Haneda, H., 1996. A cross-cultural analysis of household energy use behaviour in Japan and Norway. Energy Policy 24, 795–803.

Wilson, C., Dowlatabadi, H., 2007. Models of Decision Making and Residential Energy Use. Annu. Rev. Environ. Resour. 32, 169–203. https://doi.org/10.1146/annurev.energy.32.053006.141137

Winner, L., 1977. Autonomous technology: technics-out-of-control as a theme in political thought. MIT Press, Cambridge, Massachusetts.

Winskel, M., 2014. Embedding Social Sciences in Interdisciplinary Research: Recent Experiences from Interdisciplinary Energy Research. Sci. Cult. 23, 413–418. https://doi.org/10.1080/09505431.2014.926150

Wolfram, C., Shelef, O., Gertler, P., 2012. How Will Energy Demand Develop in the Developing World? J. Econ. Perspect. 26, 119–138.

World Bank, 2017. Pakistan - Housing Finance Project. World Bank Group, Washington, D.C.

Yaneva, A., 2009. Making the Social Hold: Towards an Actor-Network Theory of Design. Des. Cult. 1, 273–288. https://doi.org/10.1080/17547075.2009.11643291

Yin, R.K., 2014. Case Study Research: Design and Methods, 5th ed. SAGE Publications, California, US.

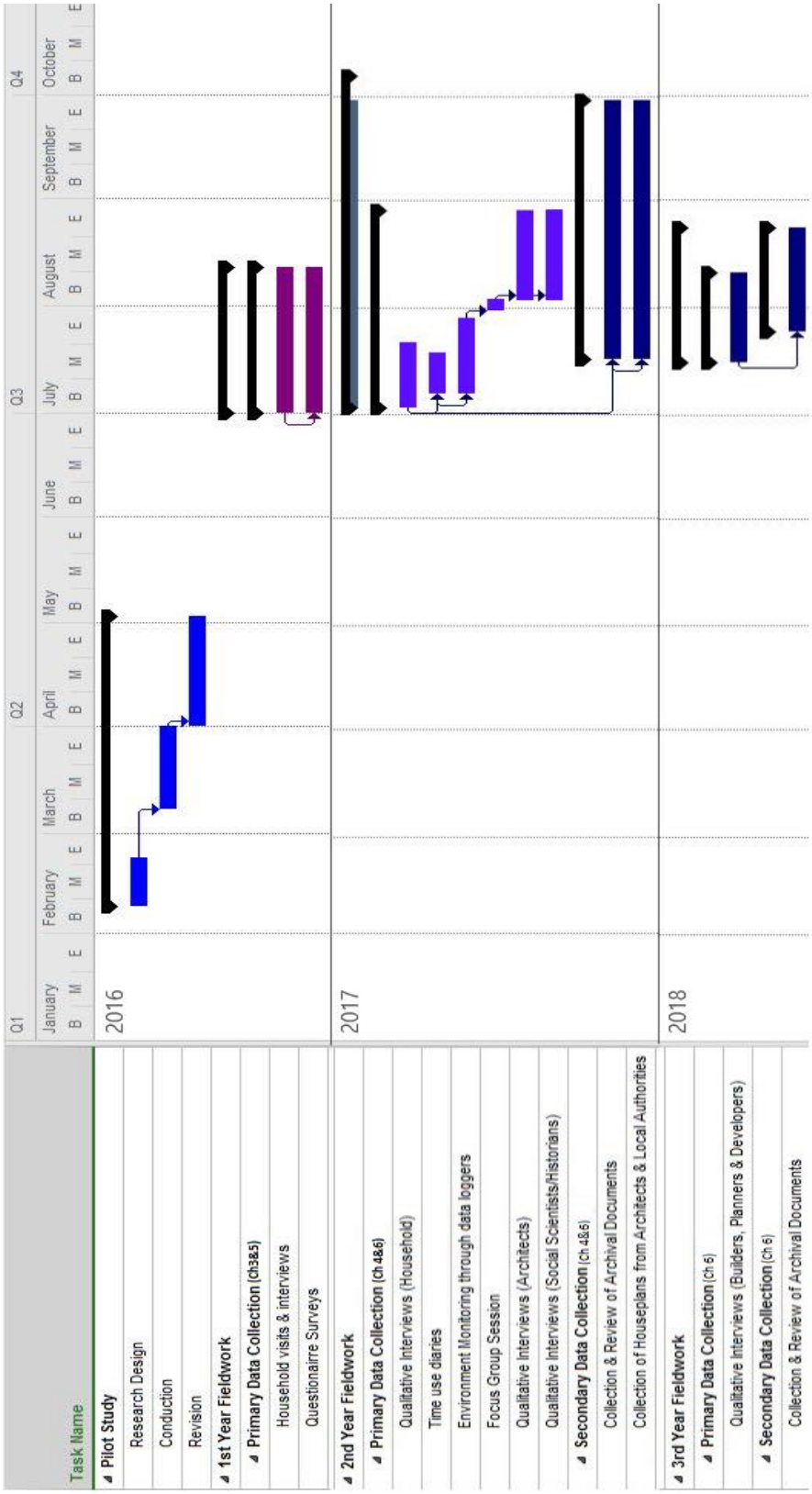
Yudelson, J., 2009. Green Building Through Integrated Design, eBook. ed, McGraw-Hill's GreenSource series. The McGraw-Hill Companies, NewYork. https://doi.org/10.1036/0071546014

Yudelson, J., Meyer, U., 2013. The world's greenest buildings: promise versus performance in sustainable design. Routledge/Taylor & Francis Group, New York.

Zhang, L., 2010. In Search of Paradise: Middle-class Living in a Chinese Metropolis, 1st ed. Cornell University Press.

APPENDICES

Appendix 1: Fieldwork timeline



Appendix 2: Semi-structured Interview with homeowners- Chapter 3

Introduction

Thank you for taking part in this research. I'm doing a PhD research project at Cambridge University and this interview is a part of my work I'm going to begin by asking you some general questions about the house and then go on to some more specific questions which relate to my research area, which is looking at domestic energy consumption in households and occupant energy practices.

If you agree then I would like to record our conversation with my voice recorder. The recording will only be listened to by me and my supervisor and it will be totally anonymous (so I won't share your names and addresses with anyone) I may use quotes from the interview in my written documentation but again these will always be anonymous

Before I begin, I'd like to ask you to sign this consent form, which states that you understand what is happening and are happy to go ahead with the interview

WARM UP

So I'll begin by asking you a few general questions about the house

1. How do you feel about your house? Are there any general things you like or dislike?
2. Who spends most time at home?
3. Type of finishes and layout? What is preferred?
4. Are there any problems in the house that they dislike or would like to change?

COMFORT

A. GENERAL PERCEPTIONS

I'd like to find out what it's like in this house and whether it’s a comfortable place to live

1. What is your notion of comfort? What makes a comfortable space?
2. Which rooms are the most frequently used? Which rooms are not except occasionally? Where does the family spend most of the time?
3. Are you generally too warm/warm/ok/cold/too cold in various rooms?
4. Any additions or adjustments made to the house to make it more comfortable over the years (how has the house evolved over the years)?
5. How much are you willing to spend money on any measures undertaken to reduce your energy consumption?

B. SEASONAL VARIATION

1. How do you maintain comfortable indoor space in summers and in winters?

C. SPACE COOLING & HEATING

1. Cooling practices? Equipment for cooling? Night time regimes?
2. What temp setting do you keep your AC on?
3. Who dictates the temp settings? Do different people have different preferences?
4. Time of use of Evaporative coolers? Months and daily use
5. Time of use of AC? Months and daily use
6. At what setting do you keep your refrigerator or freezer on?
7. How often do you get your AC or refrigerator serviced?
8. Exhaust fans? How often and when are they used?

D. VENTILATION

1. Ventilation practices? Window openings in summers and winters
2. Do you open windows? At day or night? Who does this? Why do they do it? (after cooking, shower, early morning, bedtime?) For how long?
3. When do you close them? Are they closed or open at night? Main reason for opening windows?

E. LIGHTING

1. Lighting practices? Daylight? Types of lights? Most lighted spaces?
2. On what basis you choose your lighting?
3. When leaving a room, you pay special attention to switching off lights, fans, AC?

CLEANLINESS

1. How often do you use the laundry? Laundry practices (Hand washed or machine washed, dryer?)
2. How did you choose your washing machine? How old is it?
3. When is the ironing mostly done? Who does it?
4. Do you use vacuum cleaner to clean the house? What is the general housing cleaning routine?

ICT-COMMUNICATION & ENTERTAINMENT

1. What do you generally do to relax or for entertainment?
2. What do you normally do for entertainment?
3. Who mostly watches the TV and when?
4. Who uses laptops, tablets and cell phones?
5. Do they understand standby loads?
6. When you are not using electrical equipment like TV, computers, laptop, microwave, kettle, you normally leave them…?

DAILY ROUTINE AND PRACTICES

I'd like to know about your daily practices and routines of the household

1. Daily routines: ask about a daily routine a) week-day b) weekend
2. Routines of different household members?
3. What are the appliances used daily?

CHANGE IN PRACTICES

1. How would you say your practices have changed over your life time?
2. What appliances were not used?
3. How different were your parents' practices?
4. What are the substantial changes that have occurred in your daily practices?
5. Would you want to change certain practices to those of the old times?
6. How has load-shedding affected your practices? How have your routines changed?
7. What equipment do you use to manage during those hours?
8. If load-shedding wasn't taking place anymore, how would you control your electricity use?

ENERGY CONSCIOUSNESS

A. BILLS AND METER

1. Who pays the bills? Which different types of bills do you get? What information is present on the bill?
2. Do you know what type of meter do you have? Have you ever checked the meter reading?

B. SELECTION CRITERIA

1. You normally choose an appliance based on what criteria? (brand, size, quality, cost savings, energy rating, ads)

C. ENVIRONMENT & SUSTAINABILITY

I'd like to find out what you think about issues such as the environment and sustainability?

1. What is your perception of energy use? How do you rate yourself as? Efficient, moderate or inefficient of your use?
2. Are you concerned about your consumption? what is the primary concern?
3. Are you interested in energy efficiency / saving? Why? What do you do about it?
4. Are you aware of climate change? How does this affect your life?
5. Are you concerned about your environment?
6. Would you say you actively lead a green lifestyle (recycling, ride a bike, public transport, switching off lights?)

WRAP UP

- Thanks for answering those questions. Before we move on is there anything else that you'd like to mention about what it's like living here?
- Or anything you'd like to ask me?

WALK-THROUGH PROMPTS

- Could you show me how you use your air conditioner or gas heater? When would you do this?
- Check for thermostat setting
- Check for different appliances
- Check for shading devices
- Check for any adjustments made for comfort
- Could you explain how this works...
- When would you use this...
- How often would you...

Appendix 3: Consent forms

Homeowners consent form:

PhD IN ARCHITECTURE – UNIVERSITY OF CAMBRIDGE

RESEARCH TITLE: "Energy demand and Household Practices in Developing Countries – Case-study of Lahore"

Request for participation in PhD research study

Dear ……..,

I would be very grateful for your participation and assistance in conducting a research project for the Department of Architecture, Cambridge University.

OBJECTIVE

The research is designed to facilitate in understanding the occupant domestic energy use and daily household practices in Pakistan. The study aims to understand how daily practices of comfort, cooking, cleanliness and Information and Communication Technology (ICT) and digital entertainment are undertaken by middle-income households in Pakistan. I am very much interested in understanding what factors affect day to day practices and how they have evolved over the lifetime of the occupants. The research also aims to understand how occupants perceive energy and their willingness to improve energy efficiency of their households. This is a long-term study, and once accepted, participation is expected to be for one year.

WHAT IS INVOLVED

As part of the research you will be asked to:

1. Fill out a questionnaire
2. Take part in 2-3 interviews, at various points during the two years of study.
3. Allow the researcher to take a walkthrough tour of your house with photographs.

The interviews will need to be audio-recorded for accuracy in later analysis. These will then be transcribed and analysed and direct quotations will then be used in academic publications and presentations.

ETHICAL GUIDELINES

To protect your privacy and conform to privacy laws, we would strictly observe the following rules:

1. Anonymity: Your identity will be unknown to all but the researchers on the project, Rihab Khalid, Dr Minna Sunikka-Blank and Dr. Naveed Arshad. Any information used from the visit and/or interview will be anonymised. Names, occupations and other identifying characteristics will be changed; addresses left blank; any descriptions of homes will be altered so that identification is not possible.

2. Protection of data: The digital recordings and all notes taken will be stored securely and be accessible only to the researchers mentioned. The data will not be accessible to any other personnel within or outside of their institution. After the research project is completed, including the writing of relevant publications, all this data will be destroyed.

3. Purpose use only: The information and data will be used for the findings of this research work only, and will not be used for any other project, current or future. The findings of this research project may be published

as academic articles in scientific journals and/or book chapters; as lectures and presentations for academic conferences and teaching; and in non-academic publications reporting on the findings which have been, or are being, published in academic articles, books and presentations.

4. Right to withdraw: If you agree to participate in this project, you may withdraw at any time, including after the visit and interviews. In that case, from that moment on the data pertaining to you will no longer be used, and all such data being held will be destroyed.

BENEFITS

We hope very much that you will agree to participate in this research project. Research in the developing countries is limited and the need for improved understanding and energy demand management in light of the increasing energy demand and supply gaps is critical. you can contribute towards better understanding of occupants' household energy use, identifying areas where improvements can be made and how better awareness of energy efficient practices can be designed in policies. Your participation is highly appreciated. **Please be as honest as you can as it is crucial in determining viable patterns**

If you wish to find out more about us:

Information about Rihab Khalid may be found here:
http://www.arct.cam.ac.uk/people/rihab-khalid

Information about Dr Minna Sunikka-Blank may be found here:
http://www.arct.cam.ac.uk/people/mms45@cam.ac.uk

Thank you and good wishes,

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United Kingdom

CB3 0DS

☐ I have read the information sheet and agree with all the terms of the research study

Signature: ……

Date:……

Housing practitioners (Chapter 6):

Invitation to Participate in PhD Research in Architecture

TITLE: "Energy demand in the domestic sector in developing countries: Practice-based analysis of middle-income households in Lahore"

You are being invited to take part in a research study. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

OBJECTIVE

The research is designed to facilitate in understanding the occupant domestic energy use and household practices in Pakistan. It also aims to understand the sociology of architecture and how household practices and electricity use has evolved over time, particularly in the last century with the advent of electricity supply in households. The objective is to determine more sustainable pathways for improved energy efficiency and demand management of households in the future.

WHAT IS INVOLVED

As part of the research you will be asked to take part in an audio-recorded interview.

CONFIDENTIALITY

If you wish to remain anonymous, complete anonymity will be ensured and any information provided will be kept CONFIDENTIAL and used only for this research. The recordings of interviews will only be heard by the researcher and her supervisor and all names and affiliations will be anonymised for use in research documentation. Participation is on voluntary basis.

Yes, I wish to remain anonymous ☐

BENEFITS

By taking part in this research, you can contribute towards better understanding of occupants' household energy use, identifying areas where improvements can be made and how better awareness of energy efficient practices can be designed in policies. Your participation is highly appreciated.

CONTACT DETAILS

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Address: Churchill College,
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United Kingdom.
CB3 0DS

☐ I have read the information sheet and agree with all the terms of the research study

Name: ……

Signature: …… Date: ……

Appendix 4: Questionnaire survey for homeowners- Chapter 3

DOMESTIC ENERGY CONSUMPTION IN PAKISTAN QUESTIONNAIRE SURVEY

Name:		
Full Address		
Size of House (Plot Size)		
Year of construction of house		
Number of years living in the house		
Bought or self-built		
Number of Bedrooms		
Number of Occupants		
Age of all occupants	**Name/Designation** (e.g. Son, Grandson)	**Age**
Education level of all occupants	**Name/Designation** (e.g. Son, Grandson)	**Education level** (e.g. FA, MA, MSC)

LIST OF ALL ELECTRICAL APPLIANCES IN HOUSEHOLD

1. LIGHTING

TYPE OF LAMP	Number of Lamps	No. of these used on daily basis
□ Incandescent		
Fluorescent Tube light		
□ CF Energy Saver		
□ Other _____		
Are there any Occupancy sensors/Photo sensors in your home?		
Does the lighting in your home have dimming and/or time controls?		

When leaving a room, you pay special attention to switching off lights? (*Circle one*)

No	A little bit	Somewhat	Quite a bit	Absolutely
0	1	2	3	4

ELECTRICITY GENERATION IN LOAD-SHEDDING		
	UPS	**GENERATOR**
Number		
When is it used?		
What is the capacity? *(e.g. 2 fans + 5 lights)*		
Who operates it? *(Note down all those who do)*		

2. AIR CONDITIONERS A/C

Types of A/C(s)	**A.** Through the wall/ Window AC	**B.** Split A/C	**C.** Other
Number of each type			
Number of A/C(s) being used on average at one time			
Number of months of A/C use			
At what Time of day is it mostly used? *(e.g. 6pm-5am)*			
Who mostly operates it? *(Note down all those who do)*			
What is the usual Temperature setting?			

3. VENTILATION

EVAPORATIVE COOLERS			
Total Number of coolers			
Number of coolers being used on average at one time			
At what Time of day is it mostly used? *(e.g. 11am-5pm)*			
Who mostly operates it? *(Note down all those who do)*			
Number of months of cooler usage			
FANS	**CEILING FANS**	**PEDESTAL/ BRACKET FANS**	**EXHAUST FANS**
Total Number of fans			
Number of fans being used on average at one time			
Number of months of fan usage			

4. CLEANLINESS

Total Number of washing machines	
Average use of washing machine *(Tick one)*	☐ **Daily** ☐ **Weekly**
At what Time of day is it mostly used? *(e.g. 11am-1:30pm)*	
Who mostly operates it? *(Note down all those who do)*	
Do you use Vacuum cleaner to clean the house?	☐ **Yes** ☐ **No**
If yes, how often is it used?	
At what time is it mostly used?	

5. COOKING/ EATING

A. FOOD PREPARATION

Type of Equipment	No.	At what Time of day is it mostly used?	Who mostly operates it?
Microwave oven			
Electric oven			
Electric cooker			
Electric fryer			
Electric grill			
Toaster			
Food processor			
Blender (including mixers, choppers etc)			
Kettle			
Water Dispenser			
Other: _____			

B. FOOD STORAGE

Type of Equipment	No.	Who maintains the temperature setting?	Who mostly operates it?
Refrigerator			
Freezer			

6. ENTERTAINMENT & COMMUNICATION

This will include TVs, Radios, CD players, Computers, Laptops, Mobile phones, Wireless phones, Game consoles, etc.

List of equipment	No.	At what Time of day is it mostly used?	Who mostly operates it?

7. PLEASE ATTACH A COPY OF YOUR ELECTRICITY BILL

Thank you for your participation…

Appendix 5: Extract from Interview Transcriptions- Chapter 3

I: Let's talk about lighting now. Are lights used at day time?
Mr. Fareed: Other than in the bathrooms, no.

I: So which type of lights do you have installed in the house?
Mr. Fareed: Initially, we had bulbs and tube-lights. Then we switched to energy savers, around 2002. All tube-lights were removed. We started switching to SMDs the year before last. We just wait for the old bulbs to die out, and we replace them with SMDs or LEDs. I think right now, around 30-40% energy savers are left, the rest have been converted.

I: Does everyone take care of switching off the lights when leaving a room?
Mr. Fareed: I would say the family members are careful. Us four, the elders of the house, we all do take care. We are still training our kids, telling them to at least please close the door when the AC is on, but they still refuse to understand that part. As far as the house staff….as usual they aren't really bothered about it. They have their own problems to worry about …

I would rate ourselves at 8, 10 being the highest. The reason being that in our house, we even don't have equipment on standby. We always power off equipment from the main switch.

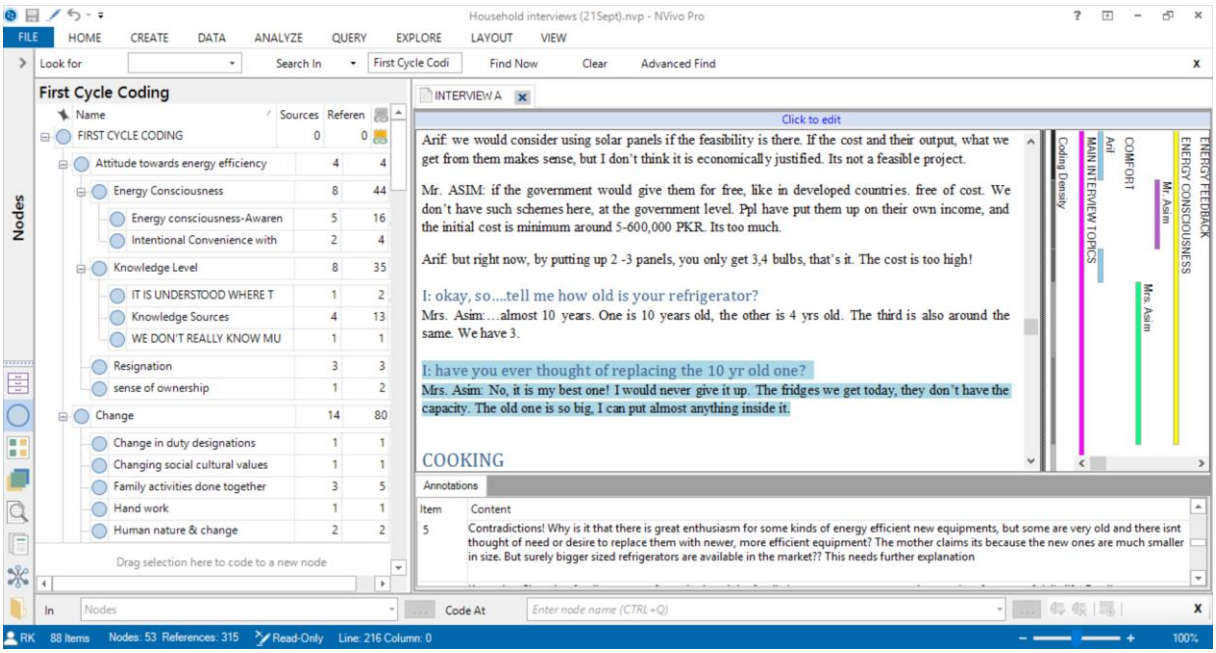
I: Does everyone in the house do that?
Mr. Fareed: My father and I definitely do, I can't say with certainty for the rest. The thing is, it is usually my responsibility to lock the house and check on everything before going to bed. So I have the habit of going around and ensuring that everything is turned off, all the doors are locked. I check that all the switches are off, and the main reason is for safety because there are small children in the house. In the daytime of course, the microwave is switched on continuously, and only switched off at night from the main switch.

I: Tell me about your laundering practices
Mr. Fareed: We have two washing machines., one of the ground floor, manually operated; the other on the top floor, fully automatic. The one on the ground floor is operated by the maid and she usually starts laundering around 9-9:30am. The one on the top floor is operated personally by my wife. She is a bit concerned about her laundry and her stuff, she doesn't like anybody else touching it. Its fully-automatic. She usually does it early in the morning, around 6:30-7am. She wakes up early with us, when the children have to go to school and I have to go to the office. So by the time we are having breakfast, her laundry is almost done. Usually the one on the ground floor is used for washing the bigger household items, like bedsheets and towels and such. Both are used daily. You can say comfortably that 5 days a week both are used. We also have a dryer, which is used occasionally in winters.

I: What about the ironing?
Mr. Fareed: Ironing is usually done in the morning as well. But around 60% of our ironing is actually out-sourced. It's just much easier and convenient this way. Instead of putting in the effort and energy at home, it's just so much more convenient to get them done from outside.

I: Do you use the vacuum cleaner for cleaning?
Mr. Fareed: Yes, we do, but not a lot. Usually twice or thrice a week. Although mostly we have tiled flooring, but we do need to clean the rugs and all. Other than this, another major cost we have is that of the air blower. Every fortnightly, the servants use the air blower to clean the windows and window sills. It's also done in the mornings because it's used on solar energy.

Appendix 6: Extract from NVivo Analysis – Chapter 3 and 4



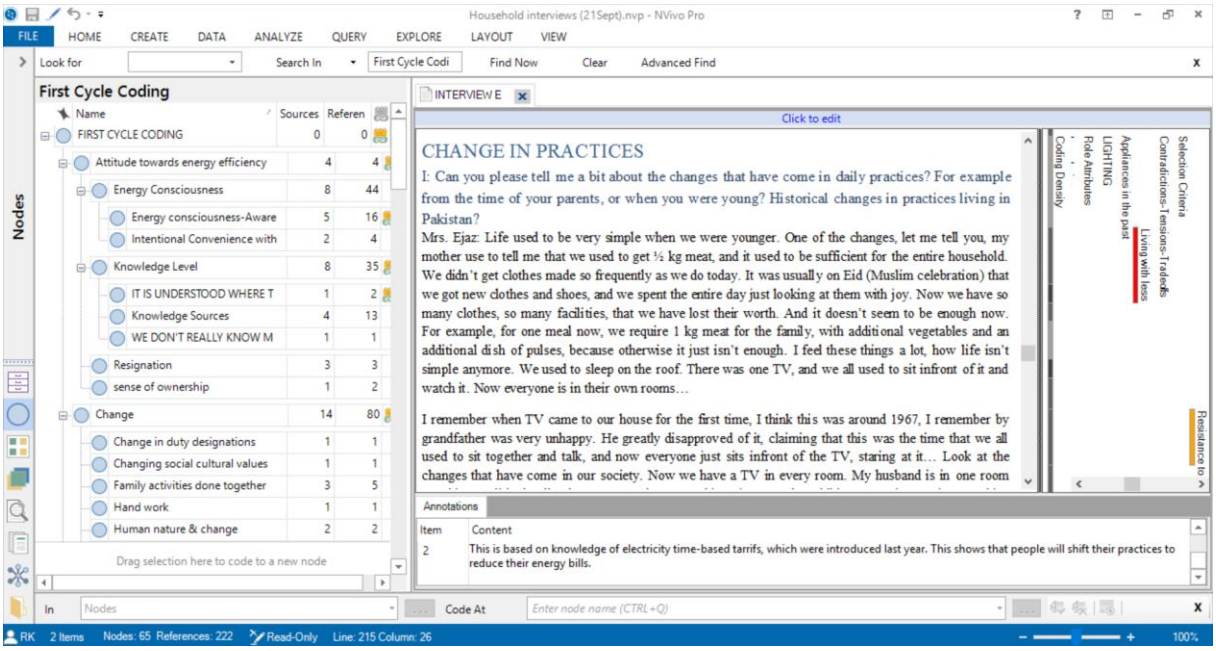


Figure: Word Cloud from NVivo analysis

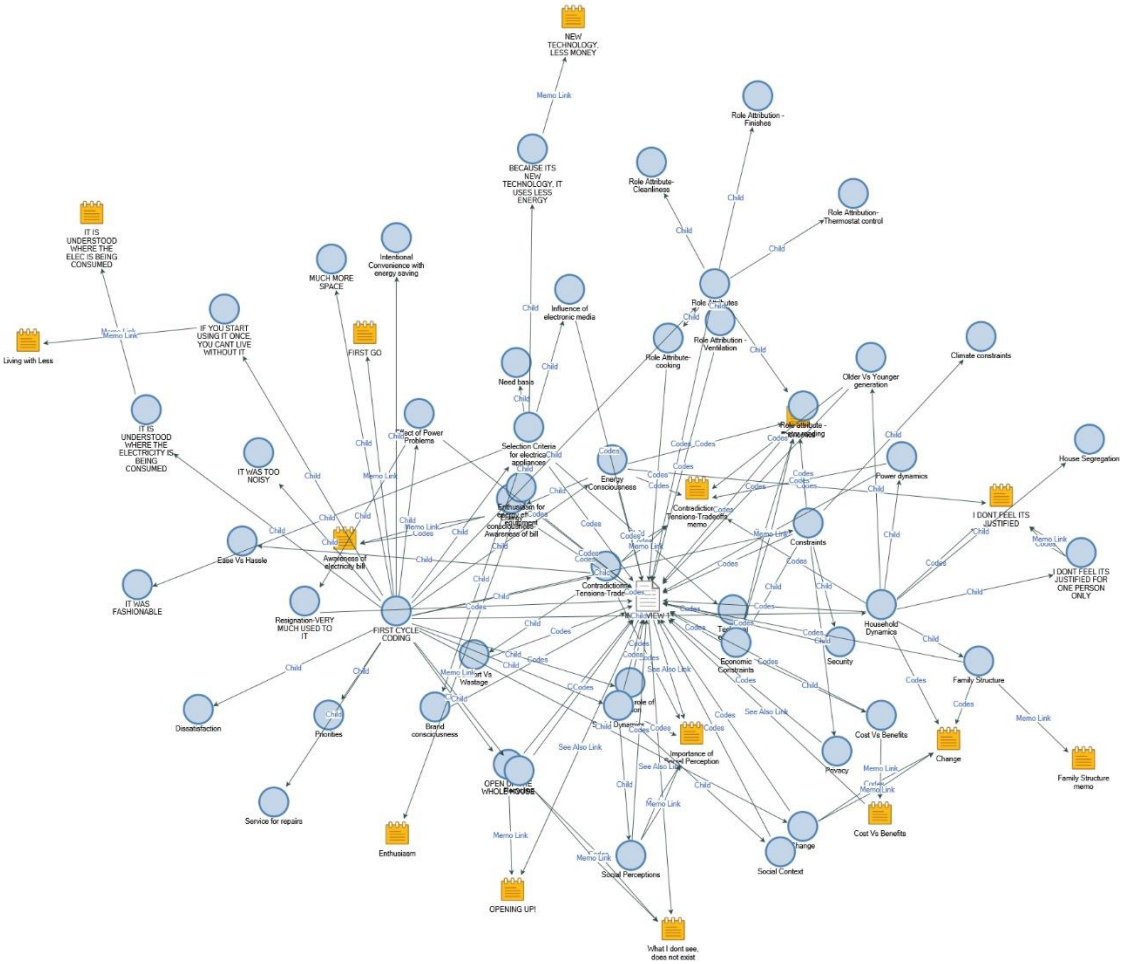


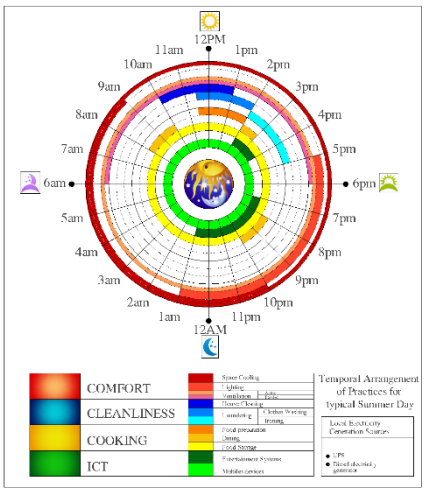
Figure: Cluster mapping for Interview A

Appendix 7: First cycle coding- Chapter 3

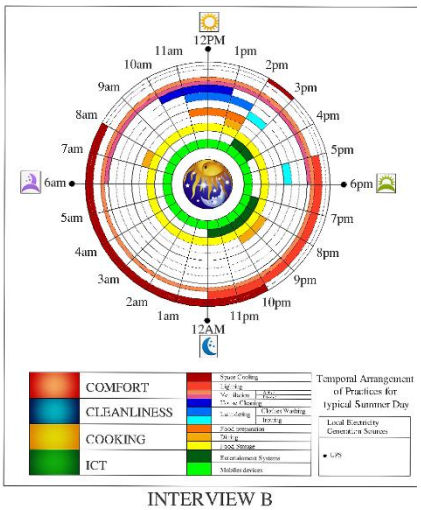
FIRST CYCLE CODING
Attitude towards energy efficiency
Energy Consciousness
Energy consciousness- Awareness of bill
Intentional Convenience with energy saving
Knowledge Level
IT IS UNDERSTOOD WHERE THE ELECTRICITY IS BEING CONSUMED
Knowledge Sources
WE DON'T REALLY KNOW MUCH ABOUT THEM- hesitation
Resignation
sense of ownership
Change
Change in duty designations
Changing social cultural values
Family activities done together
Hand work
Human nature & change
Improved control of electricity use
Inefficient changes
Life outdoors
Living according to the times
Living with less
IF YOU START USING IT ONCE, YOU CAN'T LIVE WITHOUT IT
Resistance to change
Taking things for-granted
Constraints
Climate constraints
Economic Constraints
Cost Vs Benefits
Cost Vs Cleanliness-health
Likes Vs Non-functionality
Security
Contradictions & Trade-offs
Comfort & Convenience
Rebound effect
Household Dynamics
Family Structure
Gender disparities
I DONT FEEL ITS JUSTIFIED FOR ONE PERSON ONLY
Hospitality
House Segregation
Older Vs Younger generation
Power dynamics
Role of house staff

Links between practices
Physical attributes of house
IT WAS TOO NOISY
MUCH MORE SPACE
OPEN UP THE WHOLE HOUSE
Privacy
Priorities
Privilege
Recycling
Religious Context
Renewable Energy
Convenience
Role Attributes
Role attribute - meter reading
Role Attribute- Cleanliness
Role attribute- Equipment selection and procurement
Role Attribute-cooking
Role attribute-paying the bills
Role Attribute-Security checks
Role Attribution - Finishes
Role Attribution - Ventilation
Role Attribution-Thermostat control
Selection Criteria
Aesthetics
BECAUSE ITS NEW TECHNOLOGY, IT USES LESS ENERGY
Brand consciousness
BROUGHT FROM ABROAD
COMFORT
Convenience
Efficiency
Enthusiasm for energy efficient equipment
Influence of electronic media
IT WAS FASHIONABLE
Need basis
Quality
Space requirements
THE MORE EXPENSIVE, THE BETTER IT IS
Social Dynamics
Social Context
Social Perceptions
What comes with the Neighbourhood

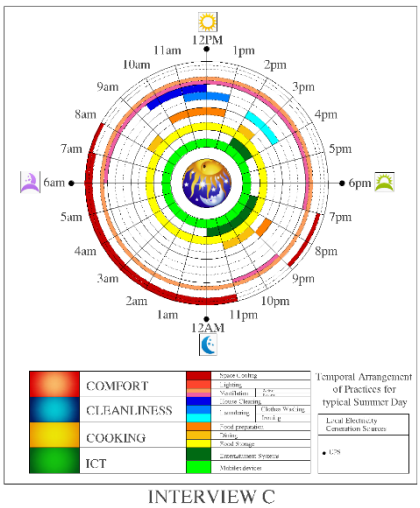
Appendix 8: Temporal arrangement of practices- Interview A-J, Chapter 3



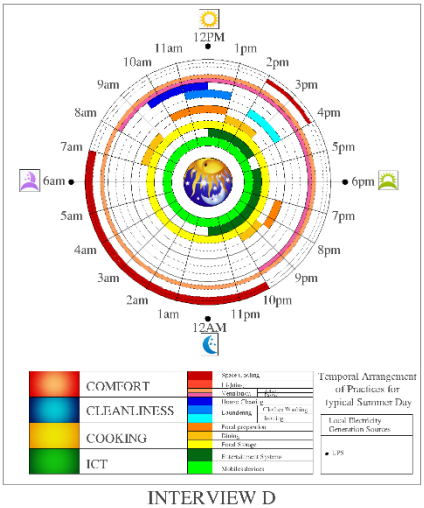
INTERVIEW A



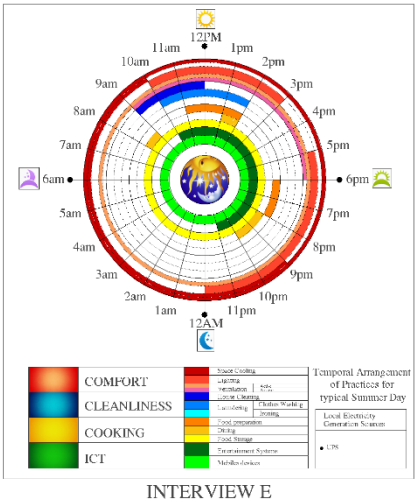
INTERVIEW B



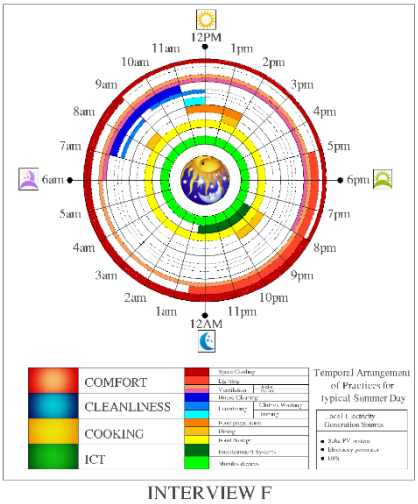
INTERVIEW C



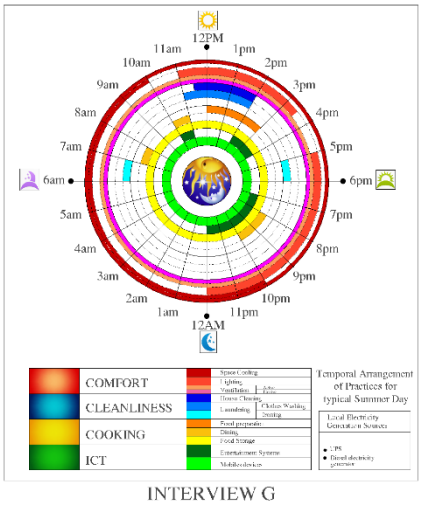
INTERVIEW D



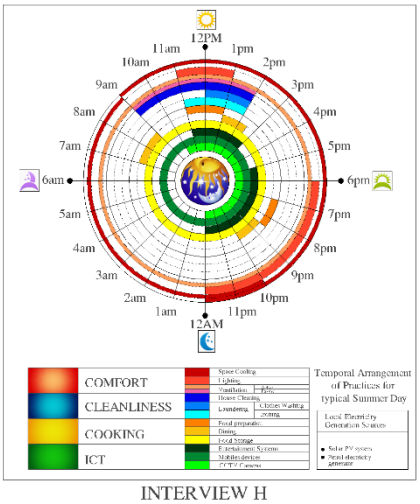
INTERVIEW E



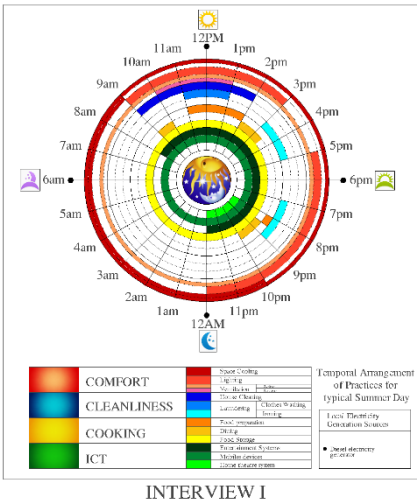
INTERVIEW F



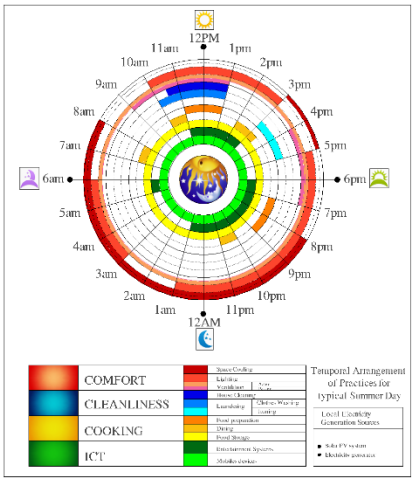
INTERVIEW G



INTERVIEW H



INTERVIEW I


12PM
1pm
2pm
3pm
4pm
5pm
6pm
7pm
8pm
9pm
10pm
11pm
12AM
1am
2am
3am
4am
5am
6am
7am
8am
9am
10am
11am
COMFORT
CLEANLINESS
COOKING
ICT
Temporal Arrangement of Practices for typical Summer Day
Local Electricity Generation Sources

INTERVIEW J

Appendix 9: Spatiotemporal arrangement of practices, case-study houses Chapter 6

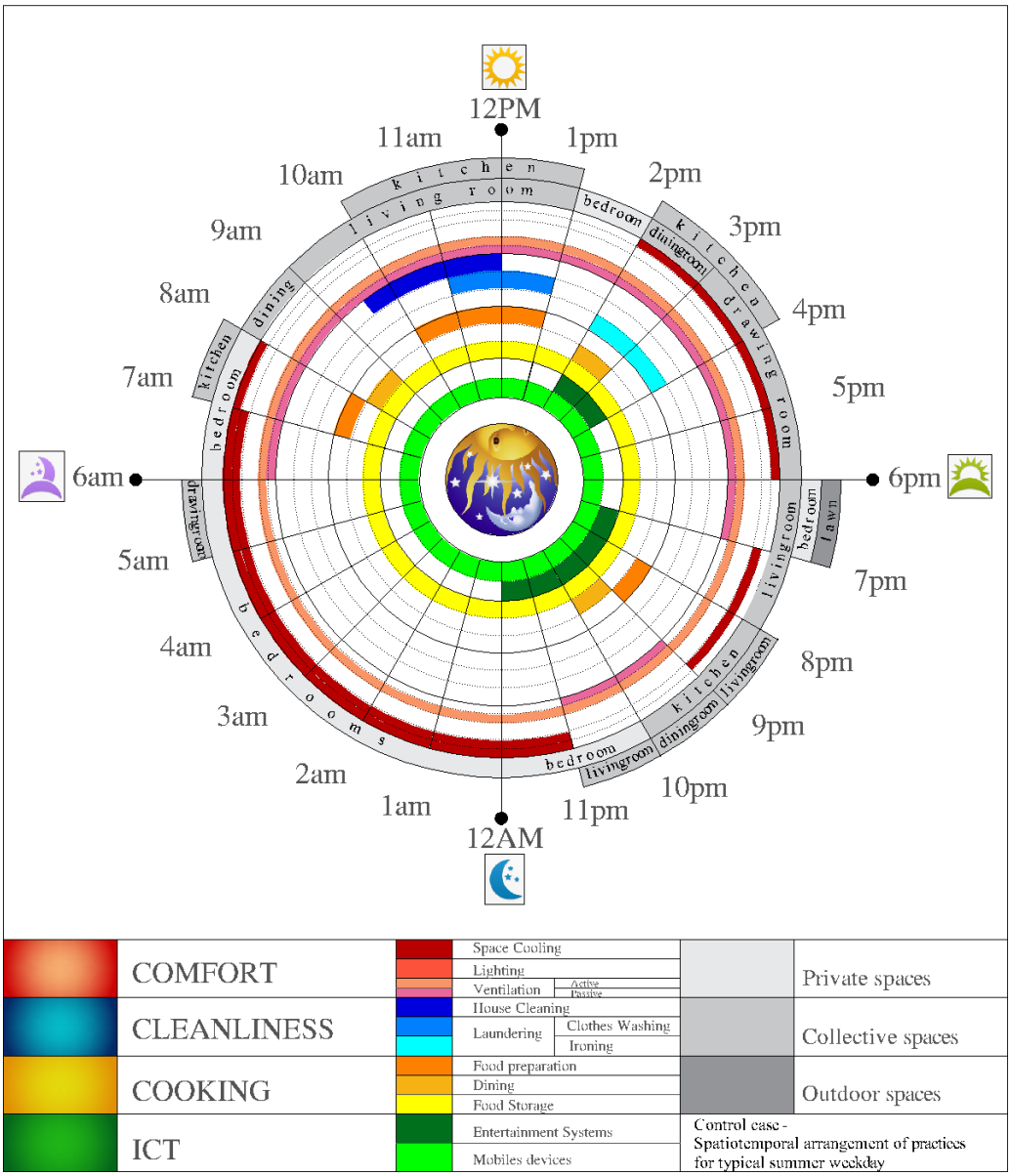


Figure: Spatiotemporal arrangement of practices for typical summer weekday- Conventional case

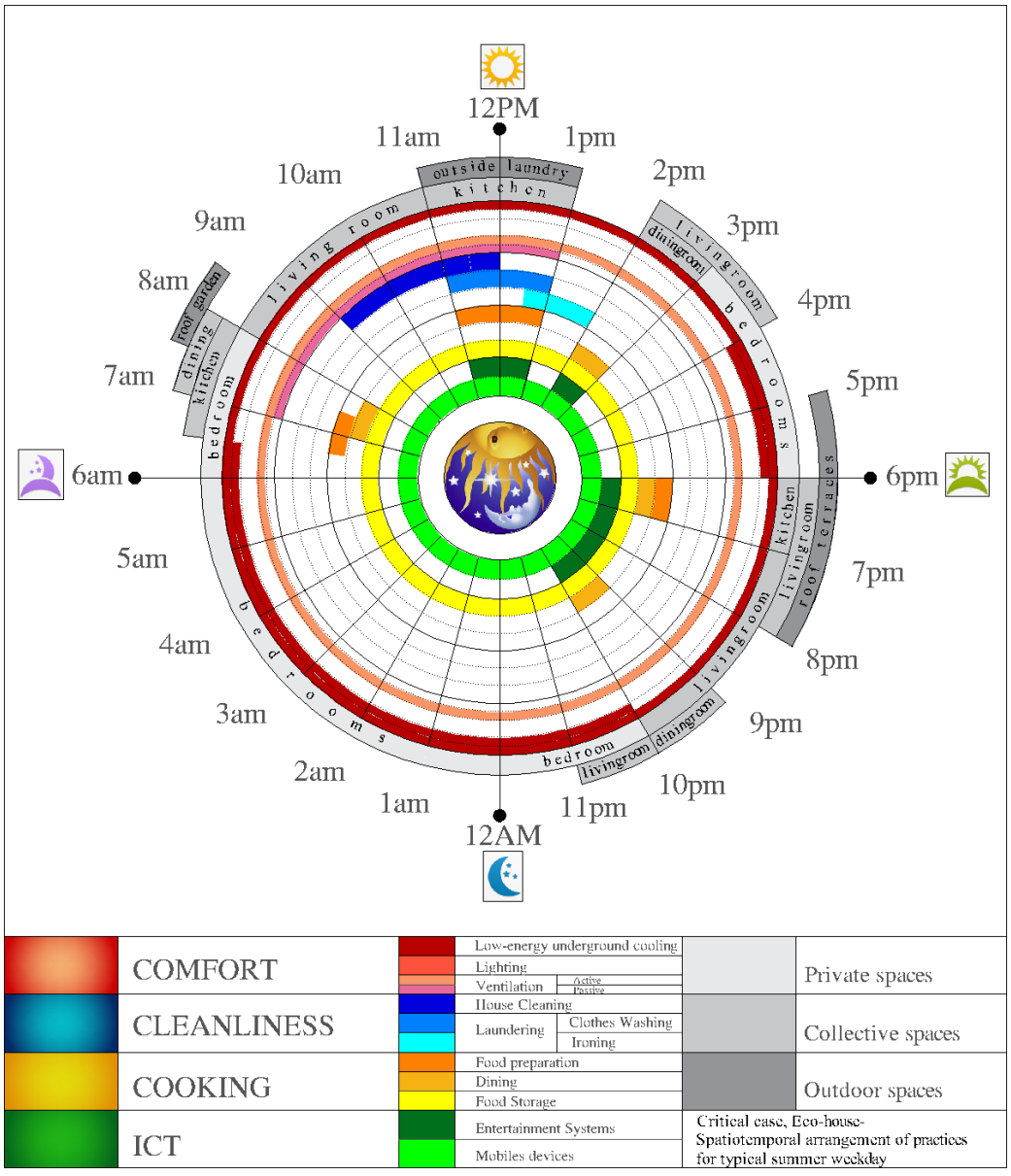


Figure: Spatiotemporal arrangement of practices for typical summer weekday- Low-energy house

Appendix 10: Temperature and humidity data, case-study houses Chapter 6

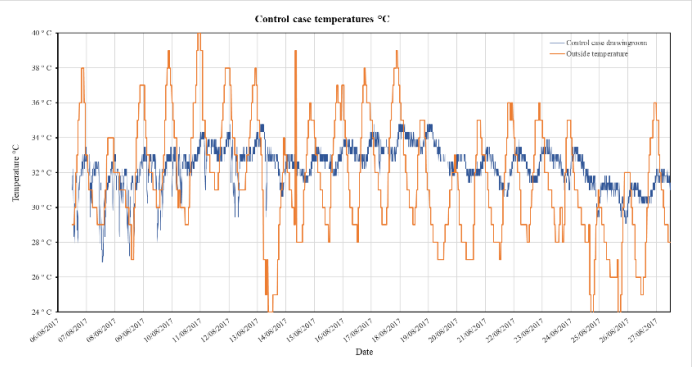
Control case: Conventional house Temperature calculations 7th-27th August 2017

Drawing room

Control case drawingroom temperature

	Percentiles	Smallest		
1%	28.689	26.85		
5%	30.22	26.85		
10%	31.008	26.85	Obs	6,048
25%	31.812	26.85	Sum of Wgt.	6,048
50%	32.633		Mean	32.32806
		Largest	Std. Dev.	1.208189
75%	33.05	34.765		
90%	33.898	34.765	Variance	1.459721
95%	33.898	34.765	Skewness	-.8040649
99%	34.765	34.765	Kurtosis	4.307817

	Mean	Std. Err.	[95% Conf.	Interval]
cdwgtemp	32.32806	.0155356	32.29761	32.35852

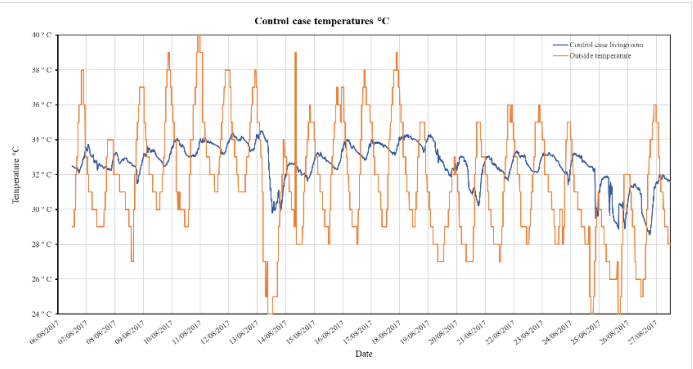


Living room

Control case livingroom temperatures

	Percentiles	Smallest		
1%	29.02825	28.54671		
5%	30.15827	28.55869		
10%	31.12093	28.56917	Obs	6,048
25%	32.20691	28.57666	Sum of Wgt.	6,048
50%	32.8339		Mean	32.65171
		Largest	Std. Dev.	1.148106
75%	33.43626	34.50102		
90%	33.94716	34.50261	Variance	1.318148
95%	34.09121	34.52172	Skewness	-1.151312
99%	34.29268	34.52331	Kurtosis	4.359697

	Mean	Std. Err.	[95% Conf.	Interval]
clivingtemp	32.65171	.0147631	32.62277	32.68065

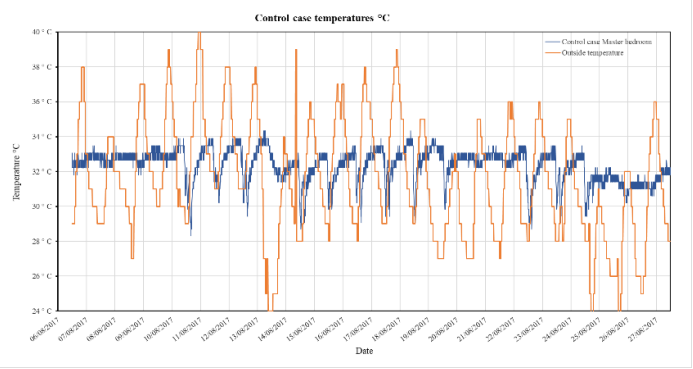


Master bedroom

Control case bedroom temperatures

	Percentiles	Smallest		
1%	29.447	28.314		
5%	30.612	28.689		
10%	31.008	28.689	Obs	6,048
25%	31.812	28.689	Sum of Wgt.	6,048
50%	32.633		Mean	32.33601
		Largest	Std. Dev.	.9336903
75%	33.05	34.329		
90%	33.471	34.329	Variance	.8717775
95%	33.471	34.329	Skewness	-.9554814
99%	33.898	34.329	Kurtosis	3.957771

	Mean	Std. Err.	[95% Conf.	Interval]
cbedtemp	32.33601	.012006	32.31247	32.35954



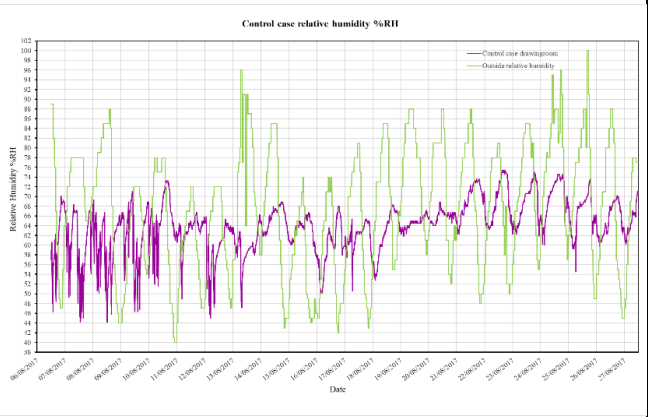
Control case: Conventional house Humidity calculations 7th-27th August 2017

Drawing room

Control case drawingroom humidity

	Percentiles	Smallest		
1%	48.032	44.151		
5%	54.088	44.151		
10%	57.12	44.151	Obs	6,048
25%	61.454	44.151	Sum of Wgt.	6,048
50%	64.064		Mean	63.94709
		Largest	Std. Dev.	5.299209
75%	67.109	75.389		
90%	70.589	75.389	Variance	28.08161
95%	73.204	75.389	Skewness	-.5644796
99%	74.515	75.389	Kurtosis	3.909136

	Mean	Std. Err.	[95% Conf.	Interval]
cdwghum	63.94709	.0681405	63.81351	64.08067

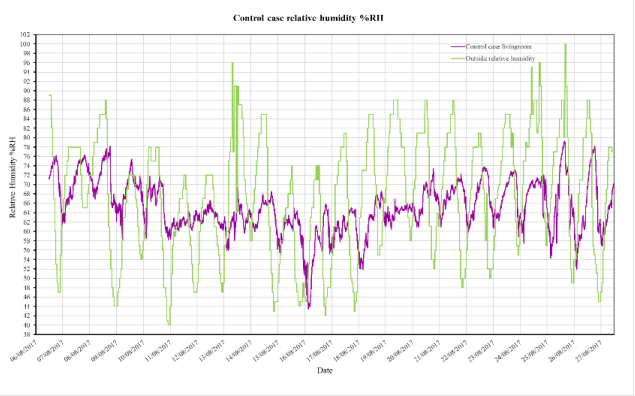


Living room

Control case livingroom Humidity

	Percentiles	Smallest		
1%	51.333	43.448		
5%	56.468	43.448		
10%	58.813	43.692	Obs	6,048
25%	61.772	43.692	Sum of Wgt.	6,048
50%	64.731		Mean	65.16696
		Largest	Std. Dev.	5.49385
75%	69.304	79.032		
90%	72.564	79.032	Variance	30.18238
95%	74.813	79.313	Skewness	-.1551254
99%	77.344	79.313	Kurtosis	3.549574

	Mean	Std. Err.	[95% Conf.	Interval]
clivinghum	65.16696	.0706433	65.02847	65.30544

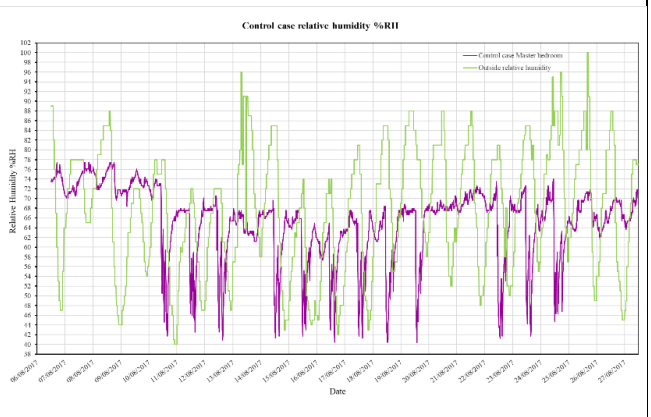


Master bedroom

Control case bedroom humidity

	Percentiles	Smallest		
1%	42.552	40.453		
5%	48.446	40.453		
10%	54.361	40.453	Obs	6,048
25%	62.851	40.453	Sum of Wgt.	6,048
50%	67.113		Mean	65.20379
		Largest	Std. Dev.	7.442008
75%	70.103	77.388		
90%	73.099	77.388	Variance	55.38348
95%	74.813	77.388	Skewness	-1.158518
99%	76.529	77.388	Kurtosis	4.200781

	Mean	Std. Err.	[95% Conf.	Interval]
cbedhum	65.20379	.0956939	65.0162	65.39139



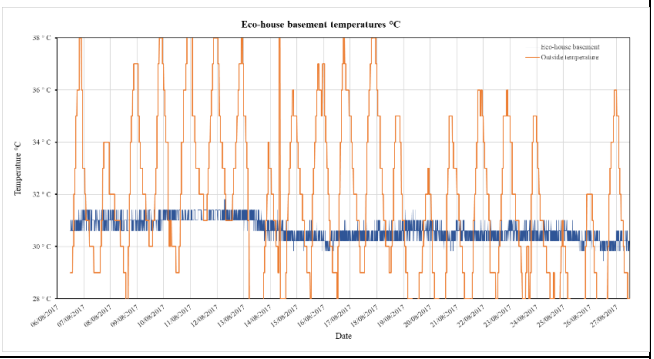
Critical case 2: Eco-house Temperature calculations 7th-27th August 2017

Basement

Eco-house basement temperature

	Percentiles	Smallest		
1%	29.832	29.447		
5%	30.22	29.832		
10%	30.22	29.832	Obs	6,048
25%	30.22	29.832	Sum of Wgt.	6,048
50%	30.612		Mean	30.65377
		Largest	Std. Dev.	.4023424
75%	31.008	31.408		
90%	31.408	31.408	Variance	.1618794
95%	31.408	31.812	Skewness	.2807646
99%	31.408	31.812	Kurtosis	2.268366

	Mean	Std. Err.	[95% Conf.	Interval]
ebasetemp	30.65377	.0051736	30.64363	30.66391

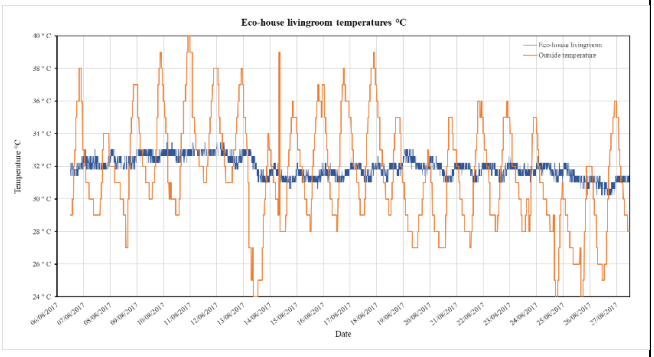


Living room

Eco-house livingroom temperatures

	Percentiles	Smallest		
1%	30.612	30.22		
5%	31.008	30.22		
10%	31.008	30.22	Obs	6,048
25%	31.408	30.22	Sum of Wgt.	6,048
50%	31.812		Mean	31.90764
		Largest	Std. Dev.	.6393922
75%	32.22	33.471		
90%	32.633	33.471	Variance	.4088224
95%	33.05	33.471	Skewness	.0783646
99%	33.05	33.471	Kurtosis	2.437216

	Mean	Std. Err.	[95% Conf.	Interval]
elivingtemp	31.90764	.0082217	31.89152	31.92375

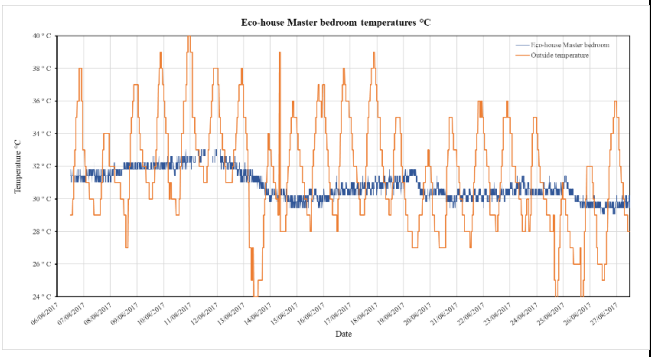


Master bedroom

Eco-house Master bedroom temperatures

	Percentiles	Smallest		
1%	29.447	29.066		
5%	29.447	29.066		
10%	29.832	29.066	Obs	6,048
25%	30.22	29.066	Sum of Wgt.	6,048
50%	30.612		Mean	30.87031
		Largest	Std. Dev.	.9090291
75%	31.408	33.05		
90%	32.22	33.05	Variance	.8263339
95%	32.633	33.05	Skewness	.4223243
99%	32.633	33.05	Kurtosis	2.231012

	Mean	Std. Err.	[95% Conf.	Interval]
embedtemp	30.87031	.0116889	30.84739	30.89322

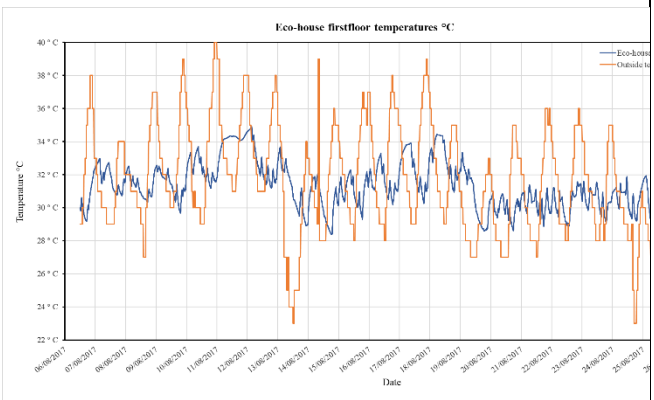


First floor

Eco-house First floor temperatures

	Percentiles	Smallest		
1%	28.37018	27.70666		
5%	28.96063	27.70963		
10%	29.31271	27.7141	Obs	6,048
25%	30.09755	27.72302	Sum of Wgt.	6,048
50%	31.03896		Mean	31.16493
		Largest	Std. Dev.	1.475648
75%	32.06981	34.87451		
90%	33.28547	34.87931	Variance	2.177537
95%	34.1673	34.88571	Skewness	.3694698
99%	34.4644	34.89371	Kurtosis	2.69127

	Mean	Std. Err.	[95% Conf.	Interval]
efftemp	31.16493	.0189748	31.12773	31.20212



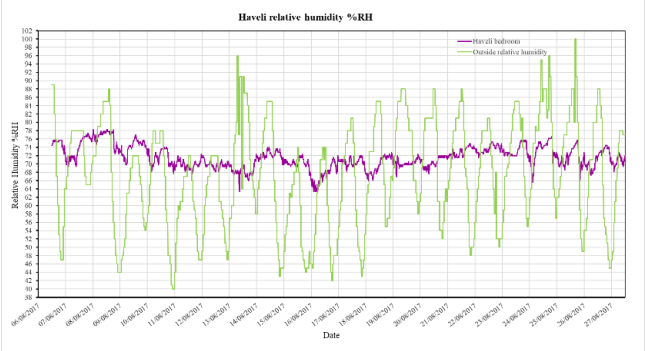
Critical case 2: Eco-house Humidity calculations 7th-27th August 2017

Basement

Eco-house basement humidity

	Percentiles	Smallest		
1%	63.853	61.708		
5%	65.141	61.708		
10%	65.571	62.137	Obs	6,048
25%	67.291	62.137	Sum of Wgt.	6,048
50%	69.874		Mean	71.54229
		Largest	Std. Dev.	5.061103
75%	77.4335	83.289		
90%	79.383	83.289	Variance	25.61476
95%	79.816	83.289	Skewness	.5323283
99%	81.551	83.289	Kurtosis	1.953618

	Mean	Std. Err.	[95% Conf.	Interval]
ebasehum	71.54229	.0650788	71.41471	71.66987

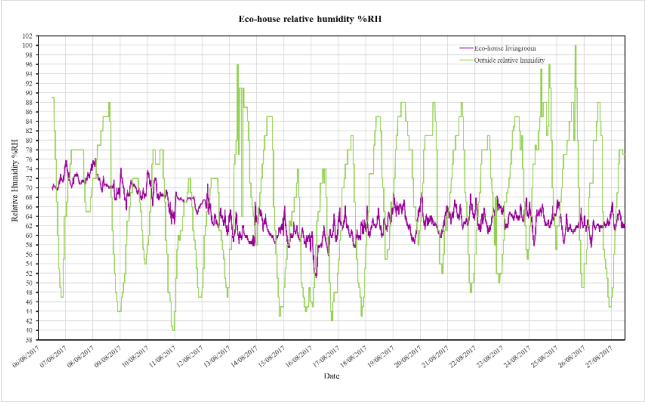


Living room

Eco-house livingroom humidity

	Percentiles	Smallest		
1%	56.586	51.156		
5%	58.674	51.156		
10%	59.51	51.156	Obs	6,048
25%	61.598	51.573	Sum of Wgt.	6,048
50%	63.684		Mean	64.2879
		Largest	Std. Dev.	4.146754
75%	67.023	75.782		
90%	70.778	75.782	Variance	17.19557
95%	72.03	75.782	Skewness	.4203076
99%	74.531	76.198	Kurtosis	2.886116

	Mean	Std. Err.	[95% Conf.	Interval]
elivinghum	64.2879	.0533215	64.18337	64.39242



Master bedroom

Eco-house Master bedroom humidity

	Percentiles	Smallest		
1%	54.041	52.362		
5%	54.881	52.782		
10%	56.141	52.782	Obs	6,048
25%	57.82	52.782	Sum of Wgt.	6,048
50%	60.76		Mean	62.57052
		Largest	Std. Dev.	6.018512
75%	68.695	77.426		
90%	71.615	77.426	Variance	36.22249
95%	72.45	77.841	Skewness	.5137343
99%	74.109	77.841	Kurtosis	1.932895

	Mean	Std. Err.	[95% Conf.	Interval]
embedhum	62.57052	.0773897	62.41881	62.72224